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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr' a
10^{9}	giga	G	jĭ' ga
10^{6}	mega	M	mĕg' a
10^{3}	kilo	k	kĭl' o
10^{2}	hecto	h	hĕk' to
10	deka	da	dĕk' a
10^{-1}	deci	d	dĕs' i
10^{-2}	centi	c	sĕn' ti
10^{-3}	milli	m	mĭl' i
10^{-6}	micro	μ	mī' kro
10^{-9}	nano	n	năn' o
10^{-12}	pico	p	pē' co
10^{-15}	femto	f	fĕm' to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 9, Number 9, September 1968

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the National Center for Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the National Center for Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • National Center for Radiological Health

Reports

Detection of Elevated Fallout Levels in California, January 1967

Amasa C. Cornish and *George Uyesugi*[1]

California received a heavy fallout of radioactive debris beginning 4.5 days after a foreign nuclear device was detonated in the atmosphere on December 27, 1966. Highest air particulate levels occurred in Berkeley and Sacramento. Values obtained after allowing 3 days decay were 98 pCi/m³ of air for both. Other air sampling stations had lesser amounts of fallout and Fresno received essentially no fallout. All milksheds in California were contaminated to some extent with radioactive iodine. Del Norte and Humboldt milk with 397 and 280 pCi/liter, respectively, contained the highest concentrations of iodine–131. These values were estimated to result in thyroid doses to children of 33 and 23 mrads, respectively. The apparent half-life for iodine–131 in the environment was calculated to be 3.2 days.

Atmospheric testing of nuclear weapons by foreign nations has prompted the State of California Department of Public Health to be alert for possible environmental contamination resulting from these tests. One such test was conducted on December 27, 1966. The energy yield was reported as the equivalent of a few hundred kilotons of TNT (*1*). The location of the detonation was approximately 90 degrees east longitude and 40 degrees north latitude. The fortieth degree north latitude crosses northern California, 180 miles north of San Francisco, some 8,000 miles east of the explosion site.

Tropospheric fallout occurs in the same general latitude as the test site (*2*). California lies directly in the path of any tropospheric cloud generated west of the State on the fortieth parallel north.

Air network

The California air network, depicted in figure 1, consists of 14 stations distributed

Figure 1. California air network

[1] Mr. Cornish is senior health physicist and Mr. Uyesugi, radiochemist, both with California State Department of Public Health, 2151 Berkeley Way, Berkeley, Calif. 94704.

throughout the State. Airborne particles are collected by a continuous sampling of air filtered through a 47 millimeter-diameter membrane filter of 0.8 micron pore size, using a Gast air pump of about 80-cubic meters per day capacity. Filters at 4 stations are replaced every 24 hours at 0800 during the workweek, weekends, and holidays. The remaining 10 stations are staffed only during the workweek. Of these, samples for weekends and holidays are continuous samples of 48 hours for a 1-day holiday, 72 hours for a normal weekend, and 96 hours for the 1967 New Year's 3-day holiday weekend. Fresh fission debris from the December 27, 1966, foreign test arrived in California during the 3-day New Year's holiday.

Unfortunately, the exact arrival time cannot be determined from our air data, as only 4 stations replaced filters each day over the long weekend. Of these, only the Berkeley station showed increased fallout levels on the filter samples which were removed at 0800, Sunday, January 1. The levels of gross beta radioactivity in pCi/m³ as measured on Berkeley air samples beginning with the 24-hour sample removed December 30, 1966, are given in table 1.

As noted in table 1, radioactive debris was measured in the surface air at Berkeley sometime between midnight and 0800, January 1, 1967, approximately 4.5 days after detonation. Since the detonation site is about 8,000 miles from Berkeley, along the fortieth parallel, the radioactive debris must have traveled a minimum of 75 miles per hour to reach Berkeley in 4.5 days. The other three stations from which daily measurements were made during this time did not show arrival of the debris until January 2.

Table 1. Gross beta radioactivity in air, December 1966–January 1967 (pCi/m³)[a]

Sampling station	December 1966		January 1967				
	30	31 [b]	1 [b]	2 [b]	3 [b]	4	5
Bakersfield	0.1	0.1	0.2	14	29	5.0	0.7
Barstow [b]	.1	.1	.1	18	36	7.3	4.2
Berkeley [b]	.1	.7	16	98	38	1.5	.5
Donner Summit	.1	.3	4.0	42	34	2.4	.1
El Centro	.1	.1	.1	21	42	9.2	3.4
Eureka	.1	.4	4.6	49	39	1.2	.2
Fresno	.1	.1	.1	.1	.1	1.4	.6
Los Angeles	.1	.1	.1	22	42	2.5	1.6
Redding	.1	.1	2.2	23	19	3.1	.4
Sacramento [b]	.1	.1	.2	47	98	3.3	2.2
Salinas	.1	.1	1.2	13	10	8.0	1.8
San Bernardino	.1	.1	.1	1.3	2.6	5.9	7.7
San Diego	.1	.1	.1	3.3	6.7	7.9	1.1
Santa Rosa [b]	.1	.1	.5	43	10	2.2	1.8
Station average	0.1	0.2	2.8	35	28	4.4	1.9

[a] The error in beta air particulate analyses is approximately ±0.1 pCi/m³ at the 95-percent confidence level.

[b] Values shown in columns, December 31, January 1, 2, and 3 are analyses of daily filter samples for only 4 stations; i.e., Barstow, Berkeley, Sacramento, and Santa Rosa. All other data for those 4 days are calculated from a 4-day composite as described in the text.

The meteorological conditions about the time of January 1, 1967, are not presented in this article. However, it is not unusual for a weather front to strike Berkeley before Santa Rosa, nor is it unusual to have different fallout patterns in Los Angeles, San Bernardino, El Centro, Barstow, and San Diego. Absence of fallout at Fresno cannot be explained except by assuming that the debris did not pass over Fresno or was not deposited because of meteorological conditions.

Reasons for placing more emphasis on the Berkeley air sample are as follows:

1. this sample is located at the Berkeley radiological laboratory;

2. the sample can be counted when removed and as often as deemed necessary;

3. samples from other stations are sent to the laboratory by mail for counting and therefore arrive 2 or 3 days after removal;

4. in determining the age of the fallout, it was convenient to use the Berkeley sample because of the early count (first and second day). Also, a decision was made to determine the age of the fallout by following the decay curve of the Berkeley sample as soon as the high radiation level was detected. It was decided not to make similar studies on other samples because it was presumed that increased fallout at other stations resulted from the same event.

Air data for all 14 stations from December 30 through January 5 are shown in table 1. Daily data depicted at those stations that had a composite sample for the New Year weekend, i.e., from 0800, December 30, 1966, to 0800, January 3, 1967, were estimated by proportioning the total 4-day fallout in the same ratio as for the four known stations.

As stated previously, four stations in the California air network change samples daily. The other 10 stations remove filters only on workdays. These 10 stations, over weekends and holidays, collect samples representing 2, 3

or 4 days. Debris from the December 1966 test arrived in the middle of a 4-day air sample. Thus, each of the 10 stations indicate a single radiation level accumulated for the 4 days although it is known that the increased level did not occur until the last 2 days.

The method used to calculate the probable gross beta air levels for the 4 days of continuous sampling for the 10 stations is illustrated in table 2. Barstow was used as the model for southern California. Barstow's air levels were as shown in column 1 with the 4-day total at the bottom. The percent was calculated by dividing each of the 4 days by the total. The Los Angeles air sample was a 4-day sample with a total gross beta radioactivty of 63.6 pCi/m³. The calculated Los Angeles air levels were obtained by multiplying 63.6 by the percent in column 2.

Table 2. Calculations of gross beta radioactivity in air for Barstow and Los Angeles (concentration in pCi/m³ and percent per day)

Barstow		Los Angeles
Air levels	Percent	As calculated
0.1	0.2	0.1
0.1	0.2	0.1
18.5	34.0	21.6
35.7	65.6	41.8
54.4	100.0	63.6

For northern California, gross beta radioactivity data from Santa Rosa, Sacramento, and Berkeley were used to establish the ratio for calculating Eureka, Redding, and Salinas values. Data for calculating Eureka fallout are shown in table 3.

Table 3. Calculation of gross beta radioactivity in air in northern California (pCi/m³)

Berkeley	Santa Rosa	Sacramento	Total	Percent	Eureka
					Calculated
0.7	0.1	0.1	0.9	0.3	0.3
16	0.5	0.2	16.7	4.8	4.4
98	43	47	188.0	53.4	49.1
38	10	98	146.0	41.5	38.2
152.7	53.6	145.3	351.6	100.0	92.0

The levels measured on these samples indicated some of the highest gross beta fallout radioactivity ever detected by our network. The previous highs occurred during the intensive testing by the United States and Russia in the fall of 1962. On November 6 and 8, 1962, during that series, Donner Summit and San Bernardino had measured air concentrations of 103 and 192 pCi/m³, respectively, and on November 25, 1962, Berkeley and Santa Rosa had 94 and 99 pCi/m³, respectively. These quantities were the result of many nuclear tests; 20 in October 1962 and 9 in November 1962. The levels were high, the duration of the peak was short. Figure 2 shows the daily statewide average air radioactivity levels during the 1967 fallout incident. Each peak in figure 2 covers about 5 days, however, air levels did not return to normal, less than 0.5 pCi/m³, until March.

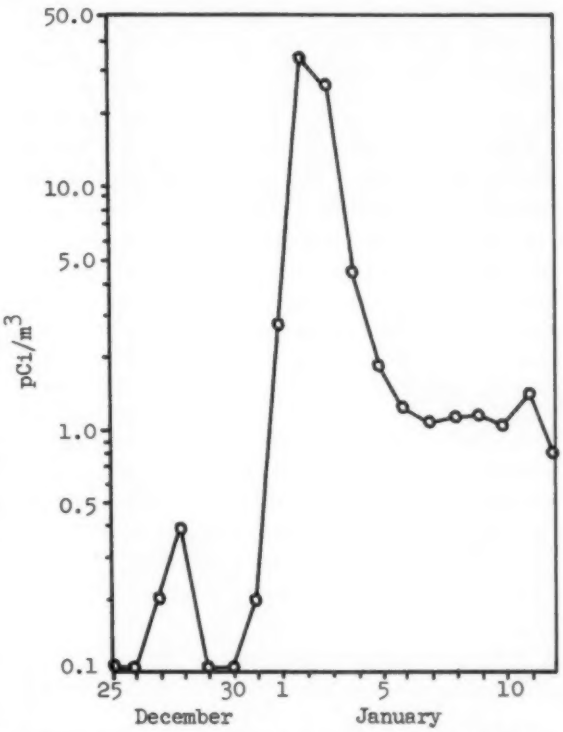

Figure 2. Radioactive air levels in California network averages, December 1966 and January 1967

The Berkeley sample removed January 2, 1967, was counted 12 times over a period of 36 days to obtain data for plotting a decay curve. The data shown in table 4 are plotted in figure 3 on special graph paper that is used

Table 4. Analysis of Berkeley air sample obtained on January 2, 1967

Date analyzed (1967)	Days after first analysis	Radioactivity (pCi/m³)	Radioactivity adjusted for plotting [a] (pCi/m³)
January 3	0	144	72
6	3	98	49
7	4	85	43
9	6	56	28
11	8	39	20
13	10	39	20
16	13	30	15
20	17	24	12
25	22	19	10
30	27	16	8
February 3	31	14	7
8	36	12	6

[a] Column divided by two so that the data will be more amenable.

for determining the age of mixed fission products (*3*). It is constructed by letting time be the abscissa, using a linear scale, and the radioactivity be the ordinate, using a scale which is made by evaluating one over the radioactivity raised to the 0.833 power ($1/A^{0.833}$). For mixed fission product fallout the plot is a straight line. Zero time on the plot is the day of the first analysis. The approximate age of the fallout is determined from the point at which the line crosses the abscissa, in this case 5.5 days.

The age of fallout also may be calculated from an equation without using the special graph paper. Using data from table 4 and letting

T_1 = time of first analysis, January 3
A_1 = 144 pCi/m³, activity on January 3
$T_2 = T_1 + 36$ days, February 8
A_2 = 12 pCi/m³, activity on February 8

then solve the equation $\log (A_1/A_2) = 1.2 \log (T_2/T_1)$ remembering that $T_2 = T_1 + 36$. Solution of the problem gives $T_1 = 5.2$ days. Thus, the fallout was 5.2 days old at the time of the first analysis on January 3. This agrees very well with the results obtained from the graphical methods.

Milk network

Milk is routinely sampled monthly from ten milksheds to determine its radioactivity. Milksheds in the program are shown in figure 4. When the December 27, 1966 detonation was announced, the sampling frequency was in-

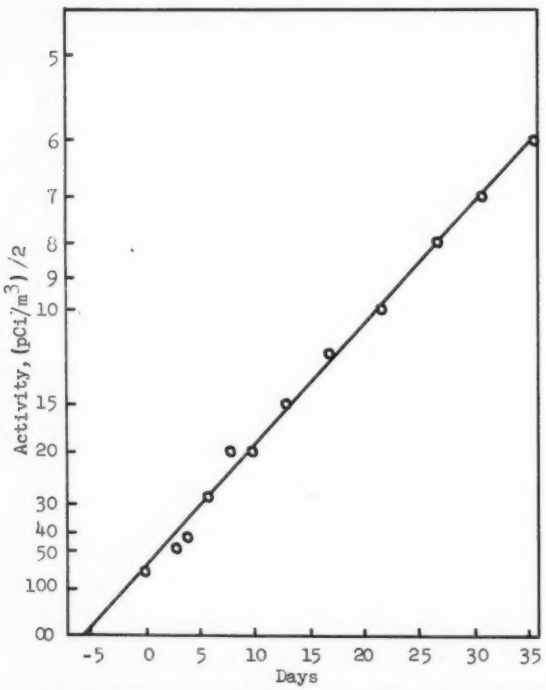

Figure 3. Decay of a Berkeley air particulate sample collected from January 1, 0800 to January 2, 0800

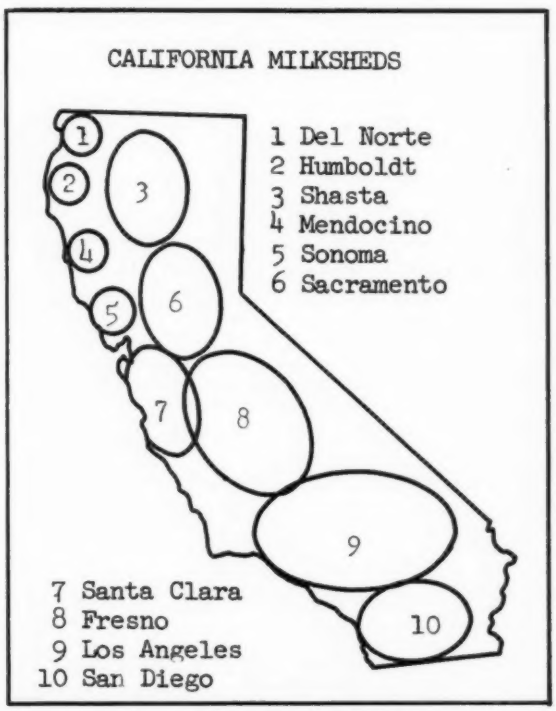

Figure 4. California milksheds

creased to daily sampling for north coastal California and to twice weekly sampling for the remainder of the network.

Analyses for iodine–131 were of prime importance for several reasons: (1) because of its short half-life, its presence is indicative of fresh fission fallout; (2) as a gamma-ray emitter having a characteristic spectrum, it can be determined rapidly; (3) it is one of the most hazardous isotopes in early fallout; and (4) because of the speed at which it can be measured, levels are used to determine the necessity of protective action. If levels become too high, recommendations can be made to convert the whole milk to powdered milk or cheese so that storage would allow the radioactivity to decay to acceptable levels. It should be emphasized that it was not necessary to take any corrective action during this incident because of any considerations including public health.

Samples from all ten milksheds showed the presence of iodine–131. Concentrations of iodine–131 in milk samples from Del Norte and Humboldt milksheds run several times higher than those found in other milksheds in California. Although there was no rain in California during the time the peak fallout cloud was over the State, some rain fell in Humboldt and Del Norte counties during the arrival and passing of the leading and trailing edges, respectively. The rains that occurred were:

Milkshed	January 1	January 4	January 5
Del Norte	0.27 inch	0.37 inch	—
Humboldt	0.08 inch	0.77 inch	0.13 inch

All other milksheds received no rain until the 19th or 20th of January. Thus, some rainout did occur but a large portion of the pasture contamination was assumed to be through dry fallout. Also, it was assumed that the contamination originated from a single event. One may then determine the effective half-life of the iodine–131 in milk from this incident.

Several investigators have determined the apparent half-life of iodine–131 on plants and in milk. The range is from 3.0 to 6.0 days according to Thompson who further states that the same variables operate regardless of the isotope involved and are related to the behavior of particles on plants (*5*). For most practical problems a useful approximation of the effective half-life of any isotope on plants is given by the following equation (*5*):

$$T_3 = \frac{13\ T_2}{13 + T_2}$$

where,

T_3 is the effective half-life (days),
T_2 is the radiological half-life (days), and
13 is the mean half-residence time (days).

If the radiological half-life of iodine–131 (8 days) is substituted in the equation, the effective half-life is calculated to be 4.95 or 5 days. The apparent half-life of the iodine–131 in Humboldt and Del Norte milk was determined assuming that the contamination originated from a single event and using the data given in table 5. Figure 5 shows this value to be 3.2 days for this specific detonation and under the prevailing climatic conditions.

Because of the early arrival of debris from the December 27 detonation there was some concern about the concentration of iodine–133 in the milk. This isotope has a 21-hour half-life. Since there was no analytical procedure available for its measurement, the concentration of iodine–133 was calculated from the known facts: the decay curves of iodine–131 and iodine–133; the relative activity of the two isotopes from uranium fission; and the known amount of iodine–131.

The two decay curves are shown in figure 6. Weaver, et al., estimated total chain and independent fission yields for several neutron-induced fission processes,

$$\text{For } ^{235}\text{U}: \frac{1.88 \times 10^6 \text{ Ci of } ^{133}\text{I/kiloton}}{1.62 \times 10^5 \text{ Ci of } ^{131}\text{I/kiloton}} = 11.6$$

$$\text{For } ^{239}\text{Pu}: \frac{1.71 \times 10^6 \text{ Ci of } ^{133}\text{I/kiloton}}{1.38 \times 10^5 \text{ Ci of } ^{131}\text{I/kiloton}} = 12.4$$

It was assumed that the activity ratio of iodine–133 and iodine–131 formed in the detonation was 12 to 1 (*6*). Figure 6 reflects this assumption in that iodine–131 at zero time was plotted as 100 and iodine–133 as 1200. Plotted in this manner, the relative amounts of the two isotopes can be selected from the graph for any given day.

Table 5. Iodine–131 in California milk, January 1967[a] (concentration in pCi/liter)

Date 1967	Del Norte	Fresno	Humboldt	Los Angeles	Mendocino	Sacramento	San Diego	Santa Clara	Shasta	Sonoma
January 3	4	[b]	62							14
4						0		21		
5		13	272					13	30	
6	397		280	30	13	41	15			35
7			190							32
8			116							31
9			78							32
10	95	49	81		12	10		30	25	38
11	104		62	10	4					5
12			88		10				19	6
13	25	28	42	17	3	15	3	17		8
14			44		13					18
15	87		24		13					
16			34		7					
17	41		29	5						
18			11		13					2
19	37		26		3					13
20					9					21
22	19		0							
24	12							0		18
25							0			
26	1			0						
27			0							

[a] The error in the iodine-131 analysis in milk is approximately ±7 pCi/liter at the 95-percent confidence level.

[b] Blanks indicate no sample received.

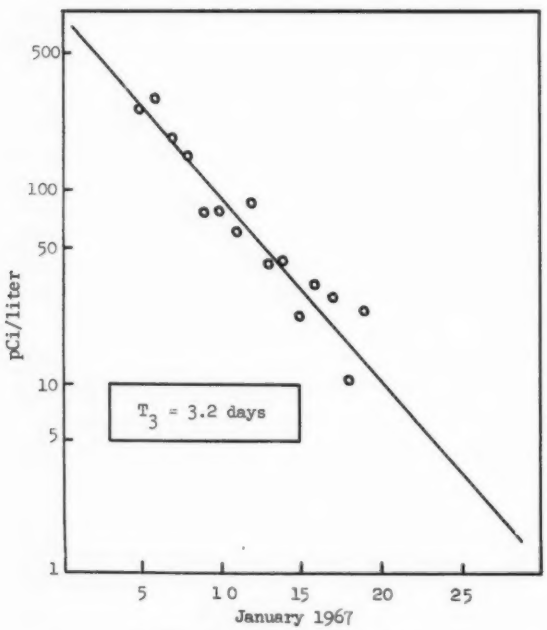

Figure 5. Humboldt milk data
Iodine–131 from foreign nuclear test, December 27, 1966

The Humboldt milk maximum iodine–131 concentration occurred on January 6, only 10 days after the detonation. Using figure 6, the relative amounts of the two isotopes on that day were 0.40 for iodine–133 and 42 for iodine–131, roughly 1 to 100. Therefore, since the Humboldt peak for iodine–131 was 280 pCi/liter, the iodine–133 concentration would be approximately 3 pCi/liter. From such calculated concentrations iodine–133 was considered to have little significance to health in this incident.

It then became important to estimate the dose resulting from drinking the milk. For the purpose of this estimation, the method used by Knapp was employed (7). It was assumed that a child had a thyroid of 2 grams (M); drank 1 liter of milk per day (L) with an incident concentration of I_o pCi iodine–131/liter of milk (400 pCi for Del Norte and 280 pCi for Humboldt); and that the fraction (F) of ingested iodine–131 taken up by the thyroid gland was 0.3. Accordingly, the dose from the fallout deposition in Del Norte and Humboldt

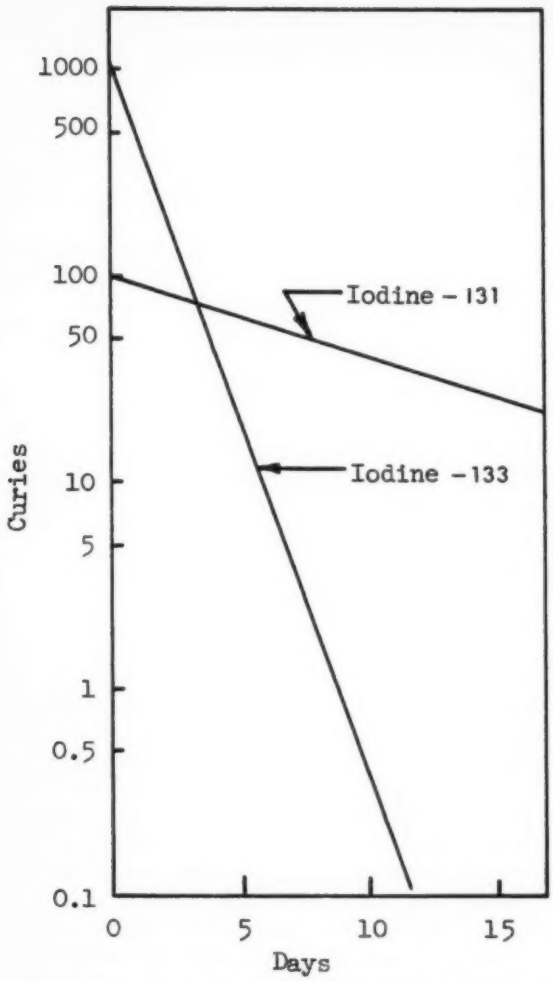

Figure 6. Decay curves for iodine–131 and iodine–133

were estimated as follows, using T_3 equal to 3.2 as already determined:

Dose in rads = (1.71×10^4) LFI_0T_3/M; hence
Del Norte dose = 0.033 rads, and
Humboldt dose = 0.023 rads

For Del Norte and Humboldt children, the estimated total dose to their thyroids from the deposition was 33 millirads and 23 millirads, respectively, if they drank a liter of milk per day.

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A Comparison of Results Between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 Through June 1966

Paul B. Robinson[1]

The Public Health Service Raw Milk and Pasteurized Milk Networks are compared for the interval January 1964 through June 1966 on the basis of milk sample analyses made during that period. Once laboratory effects due to analytical differences in the milk sample analyses were removed from the data, the agreement for cesium–137 and strontium–90 between four of the nine stations that were common to both networks was related to milkshed overlap. At two other stations, Cincinnati and Chicago, homogeneity in the agricultural, geographical, and meteorological parameters accounted for the similarity between the sample concentrations of cesium–137 and strontium–90. It was not possible to study iodine–131, barium–140, or strontium–89 because the levels were generally not detectable for the period under study.

A tabulation of data for all samples collected from the Raw Milk Network is also appended for the period, January 1963–December 1966.

In May 1957, the Raw Milk Network (RMN), operated by the Milk and Food Research Program of the Division of Environmental Engineering and Food Protection[2] and funded by the Division of Radiological Health[3], commenced operation. This surveillance program represented a first attempt to monitor the intake of radionuclides in the diet of people through milk sampling of milksheds serving metropolitan areas. Milk was chosen because it is produced throughout the year and was an integral part of the diet of children and young adults. Its uniform composition and continuous use made possible the development of analytical techniques for handling large numbers of samples on a routine basis. Milk and milk products are major contributors of strontium–90 and iodine–131 in the diet.

Nine RMN stations had collected samples regularly from August 1958 until the cessation of the network in December 1966. A tabulation of the monthly results for the milk analyses in the RMN is given in Appendix I for the period, January 1963 through December 1966.

It was possible to make a comparison at each station for those Raw Milk Network and Pasteurized Milk Network (PMN) analyses made at the Northeastern, Southeastern and Southwestern Radiological Health Laboratories (NERHL, SERHL, and SWRHL, respectively) for the period, January 1964 through June 1966. This comparison was facilitated because of the availability of quality control data for all three laboratories, and the fact that all raw milk analyses were performed at a single laboratory (SWRHL). Each single monthly RMN sample was compared with that weekly PMN sample most closely related in time. Occasionally two weekly PMN samples straddled the RMN sample equidistantly in time. When such was the case, the average of those data was used in the comparison. A similar summary was undertaken by Campbell (*1*) for the Raw Milk Network results from 1957–1963, however, extensive quality control data were not available for that period.

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[1] Mr. Robinson was staff officer, Radiation Exposure Intelligence Section, Standards and Intelligence Branch, National Center for Radiological Health, Rockville, Md. and is presently a member of the technical staff at the Bell Telephone Laboratories at Holmdel, N. J.

[2] Presently part of the National Center for Urban and Industrial Health, Environmental Control Administration.

[3] Presently the National Center for Radiological Health, Environmental Control Administration.

Raw Milk Network sampling program

Once a month in each of nine milksheds[4], a 1-gallon sample of raw milk was taken from a group of farms selling to one of the dairies supplying the station with pasteurized milk. This sample represented a 1-2 day composite of the milk produced on these farms.

The farms were chosen to satisfy four criteria (*2,3*) :

(1) the milk represented in each sample was from a group of farms milking a total of at least 1,000 cows.

(2) the number of individual farms was small enough so that collection of collateral farm data from each farm was feasible.

(3) the milk samples were from a supply that was part of a metropolitan milkshed.

(4) the conditions under which the milk was received were such that each sample was representative of the same farms in the production area.

Wherever possible, the group of farms that were chosen were located along a tank-truck route or a can-truck route. In this case the milk sample would be representative of a 1-day supply. It normally took 1 to 2 days to separately sample each form.

The introduction of the PMN made possible the collection of a weekly composite sample of pasteurized milk which was representative of from 80 to 100 percent of the milk sold at each of the nine stations. Figure 1 presents qualitatively the RMN-PMN relationship.

[4] For purposes of this paper, raw milk milkshed areas are defined as a county or group of counties having at least one farm which regularly sells raw milk to a dairy processing plant that supplies pasteurized milk to a RMN–PMN station city.

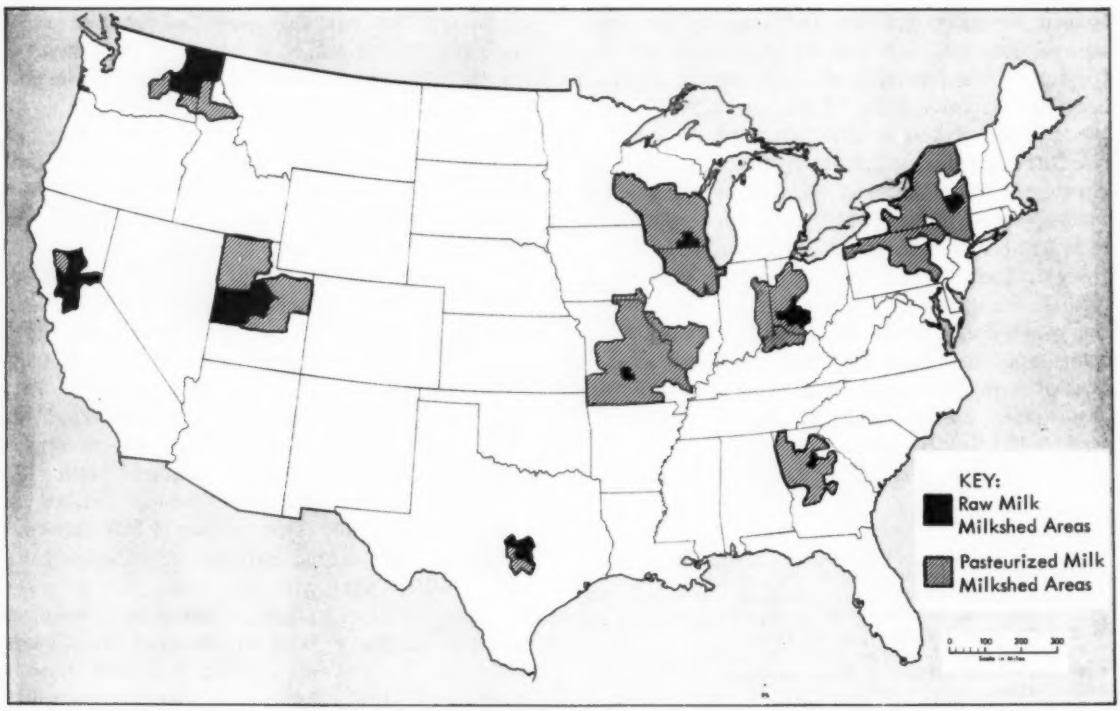

Figure 1. Outlines of RMN-PMN milkshed areas

Procedure

In order to compare the RMN with the PMN on the basis of their sampling schemes, it was necessary to consider any differences which might be present in the data due to the fact that various laboratories were involved in analyzing the samples. The analytical crosscheck data, as collected monthly by the Analytical Quality Control Service (AQCS), National Center for Radiological Health (*4*), furnished this information.

During the study period from January 1964–June 1966 [5] all raw milk samples were analyzed at SWRHL. The PMN analyses were performed on a regional basis with NERHL analyzing milk from Chicago, New York City, and Cincinnati; SERHL analyzing milk from Austin and Atlanta; and SWRHL analyzing milk from Sacramento, Spokane, Salt Lake City and St. Louis.

Adjustment of RMN and PMN data for laboratory effects

Through the auspices of the AQCS program, identical pasteurized milk samples wtih unknown concentrations of radionuclides are analyzed in triplicate at each of the three regional laboratories. This program is carried out on a monthly basis. Under the assumption that all laboratories share the same degree of internal reproducibility (*4*), the three replicate measurements of each laboratory are averaged and the range of the several laboratory means is calculated. Given that the variance of each average is known, a range control chart (*4*) can be designed to test the null hypothesis, $H_0: \mu_1 = \mu_2 = \mu_3$, against the alternative hypothesis, H_1 : the means μ_i are not equal (*4*). where μ_i (i= 1,2,3) are the sample means for each laboratory.

These monthly crosscheck data were utilized to search for and define laboratory effects in the PMN and RMN radionuclide analyses. An estimate of these effects was necessary to properly compare the two networks solely on the basis of their sampling plans.

In most cases, more than the three regional laboratories participated in these monthly crosscheck programs. Thus, with results from four or five laboratories, it was possible to estimate the concentration of each radionuclide from each month's crosscheck data, by first removing results which were statistical outliers based on the range of the results from the laboratories, and then using the average of the remaining data as an estimate of the concentration.

When an outlying value was found, it was dropped from consideration and a new range and control limits were calculated. This process was continued until some noncritical subset of laboratories participating in the crosscheck was found. This subset contained two or more laboratories whose range did not exceed the control limits. The average concentration of this subset was used as a "best" estimate for the true concentration for the particular radionuclide in the crosscheck sample. When a range was found out of control with no laboratory appearing as an outlier, a search was made of succeeding monthly samples to detect any trend (i.e., some laboratory whose results were generally above or below the values from other laboratories). If such a trend developed, that laboratory was said to be out of control for the crosscheck period and removed from further consideration. Many times it was impossible to reduce a range to a noncritical state. When such a case occurred, an estimate of the true concentration was taken as the average of all the laboratories.

From a compiled listing of these "best" estimates, a measure of the monthly bias in the nuclide determinations at each regional laboratory was computed. For the radionuclides, an incorrect calibration in the counting instruments will lead to bias which is a function of the radionuclide concentrations present. For example, the beta-particle counting of strontium–90 using an incorrect efficiency will yield a bias which is proportional to the true concentration. In gamma-ray spectrographic analysis, the bias and gain shifts yield errors which are functionally related to the interfering radionuclides and background levels. For the purpose of relating quality control data to the bias in a routine operation, the assump-

[5] The strontium–90 RMN–PMN comparisons cover the time interval, January 1964–December 1966. Calcium analysis was discontinued in March 1966.

tion was that bias is proportional to the true concentration of the radionuclide being assayed. This same assumption was used for calcium determinations. However, since the calcium levels in milk are relatively invariant, a constant bias and a constant percent bias are almost identical in this case.

For the purpose of obtaining data correction factors, least square polynomials were fitted to the bias estimates for each laboratory and each nuclide under study. From these curves estimates of the average bias for each month were obtained. Table 1 shows the resultant correction formulae obtained from this analysis. RMN and PMN data corrected for laboratory effects appear in figures 2–5.

Table 1. Correction factors for laboratory differences between the Raw Milk and Pasteurized Milk Networks

Nuclide	Laboratory	Error function
Cesium-137	SERHL	$p(t)$ [a] $= 98.3462 - 0.0970t - 0.0135t^2$
	SWRHL	$p(t) = 96.5959 - 0.0493t$
	NERHL	$p(t) = 104.2533 - 0.1959t + 0.0100t^2$
Strontium-90	SERHL	$p(t) = 101.6792 + 0.0520t + 0.0223t^2$
	SWRHL	$p(t) = 112.3912 + 0.7210t$
	NERHL	$p(t) = 95.5769 + 0.0062t$
Calcium	SERHL	$p(t) = 100.1142 - 0.0222t - 0.0036t^2$
	SWRHL	$p(t) = 106.6730 + 0.2468t - 0.0132t^2$
	NERHL	$p(t) = 98.1115 - 0.0204t + 0.0074t^2$
Potassium	SERHL	$p(t) = 99.2044 + 0.0825t + 0.0117t^2$
	SWRHL	$p(t) = 99.8155 - 0.2679t - 0.0304t^2$
	NERHL	$p(t) = 101.1462 - 0.1328t$

[a] $p(t) = 100\left[\frac{\text{estimated mean concentration}}{\text{true mean concentration}}\right]$, where t = time in months with t = 0 at July 1965 and $(-18 \leq t \leq 17)$.

Summary of results

Paired t-tests for the corrected RMN and PMN data from each of the nine stations (table 2) yielded results which for strontium–90 are similar to those of Campbell (*1*), with significant differences observed at New York City, St. Louis and Atlanta. For cesium–137, New York City and St. Louis showed significant differences in the mean concentrations. In the case of the stable elements, potassium and calcium, the only significant difference shown by this test was observed for calcium at Atlanta.

Table 3 presents correlation coefficients for the concentration of the various elements and radionuclides for each of the data sets. An analysis of table 3 shows that for strontium–90 and cesium–137 significant correlations exist between the two networks with the higher correlations consistently associated with cesium–137. During the period of comparison, January 1964–June 1966, when fallout levels were decreasing, direct aborption of cesium–137 by plants would amount to a greater degree of plant contamination than would uptake through the soil. The opposite would be the case for strontium–90 (*7*). Therefore, cesium–137 would be expected to be less affected by farming practices than strontium–90.

Calcium correlations were all insignificant. This may be interpreted to mean that labora-

Table 2. Paired t-test[a] results for internetwork comparison of mean concentrations

Nuclide	New York City	Cincinnati	St. Louis	Salt Lake City	Sacramento	Atlanta	Chicago	Spokane	Austin
Strontium-90	[b] −5.91	−0.66	[b] 10.34	−1.93	2.45	[b] 4.92	3.09	−2.09	0.53
Cesium-137	[b] −6.27	.41	[b] 5.34	−1.92	1.94	−1.15	1.55	0.42	1.51
Potassium	−0.45	− .60	−3.06	−1.22	−0.55	0.72	−0.96	.85	1.66
Calcium	2.10	.72	3.66	−1.10	1.00	4.27	.55	− .65	.31

[a] Two-tailed test at 0.002 level of significance for each individual t-test, with degrees of freedom equal to n-1, where n is the number of paired samples for a particular radionuclide at a specific station (see figures 2-5 for values of n). For the entire set of 36 t-tests, the probability of a type I error is 0.07.
[b] Significant difference.

Table 3. Correlation coefficients[a] for the two networks at each station

Nuclide	New York City	Cincinnati	St. Louis	Salt Lake City	Sacramento	Atlanta	Chicago	Spokane	Austin
Strontium-90	0.80	0.84	0.71	0.63	0.63	0.84	0.79	0.84	0.58
Cesium-137	.97	.94	.95	.79	.86	.91	.93	.96	.65
Potassium	.33	.06	.56	.03	.40	.63	.62	.28	.27
Calcium	.09	.29	.22	.03	.22	.39	.24	.26	.10

[a] To test whether p (correlation coefficient) is significantly different from zero given the tabled value of r (observed correlation coefficient) for a sample size of 30 at $\alpha = 0.002$, we have as critical points $r_{crit} \cong |0.54|$. Hence for $|r| \geq |r_{crit}|$ we can assume $p \neq 0$. For the entire set of 36 t-tests the probability of type I error is 0.07.

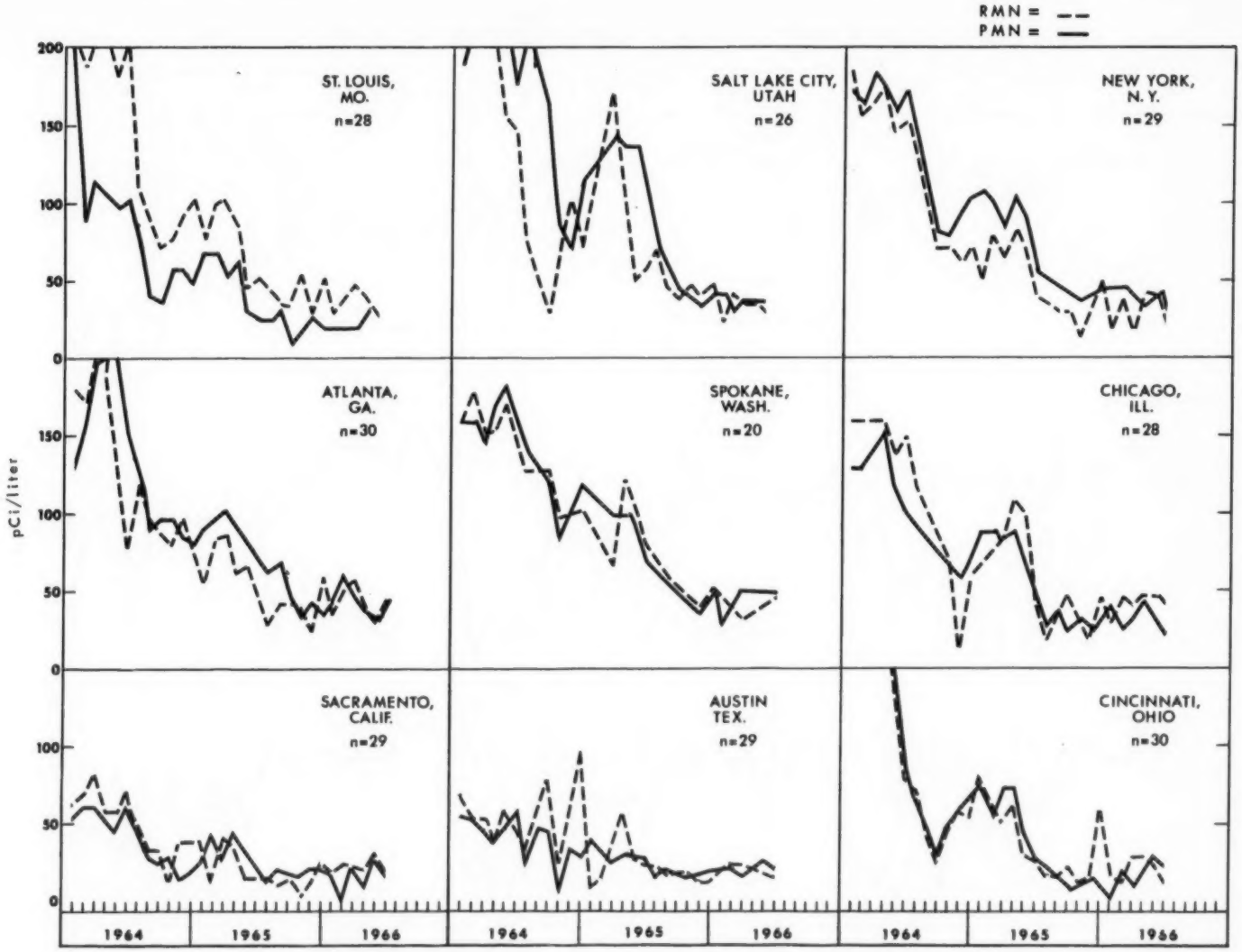

Figure 2. Cesium-137 data corrected for laboratory effects[a] n=number of paired RMN-PMN samples
[a]Unadjusted data given in Appendix 1

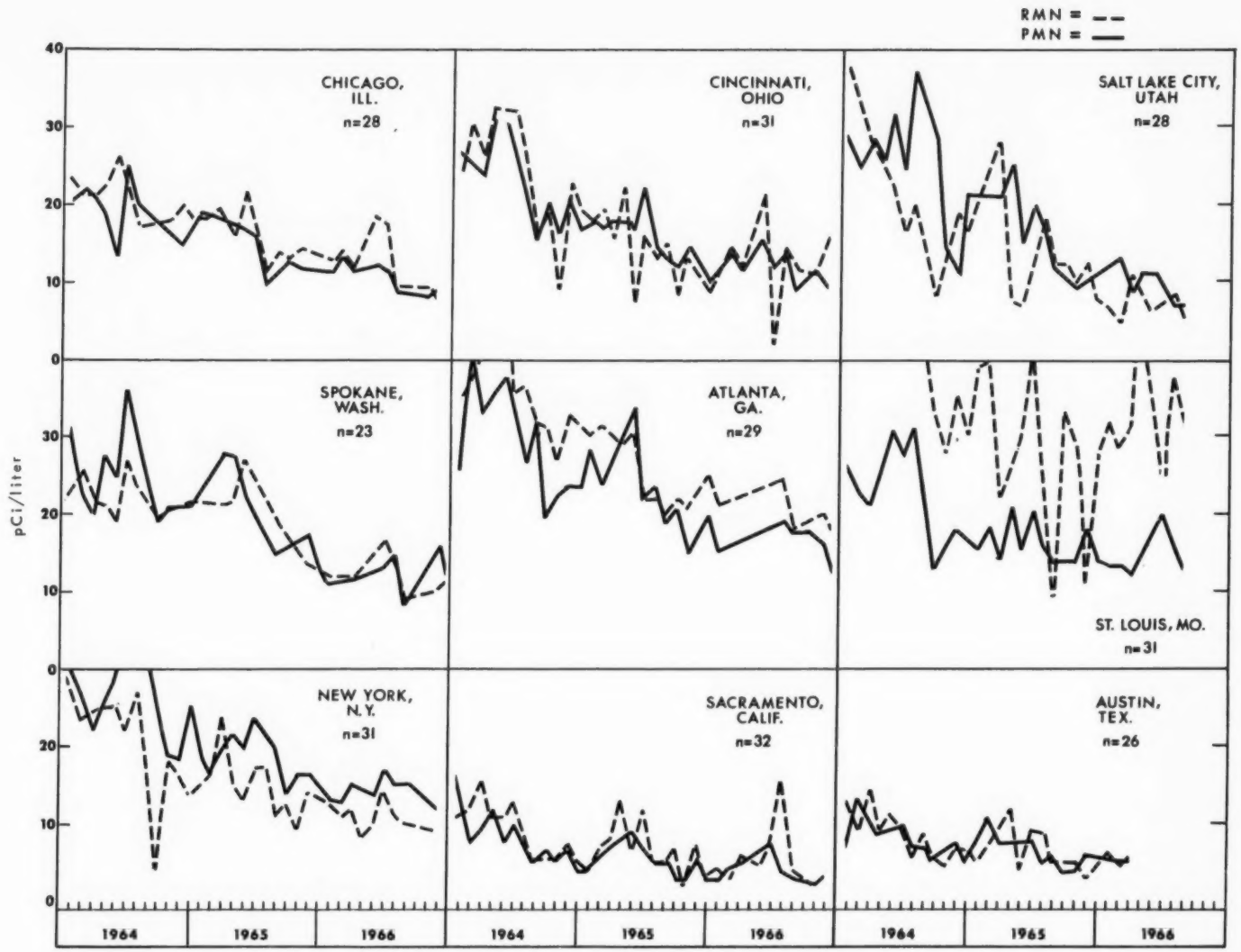

Figure 3. Strontium-90 data corrected for laboratory effects[a] n=number of paired RMN–PMN samples
[a]Unadjusted data given in Appendix 1

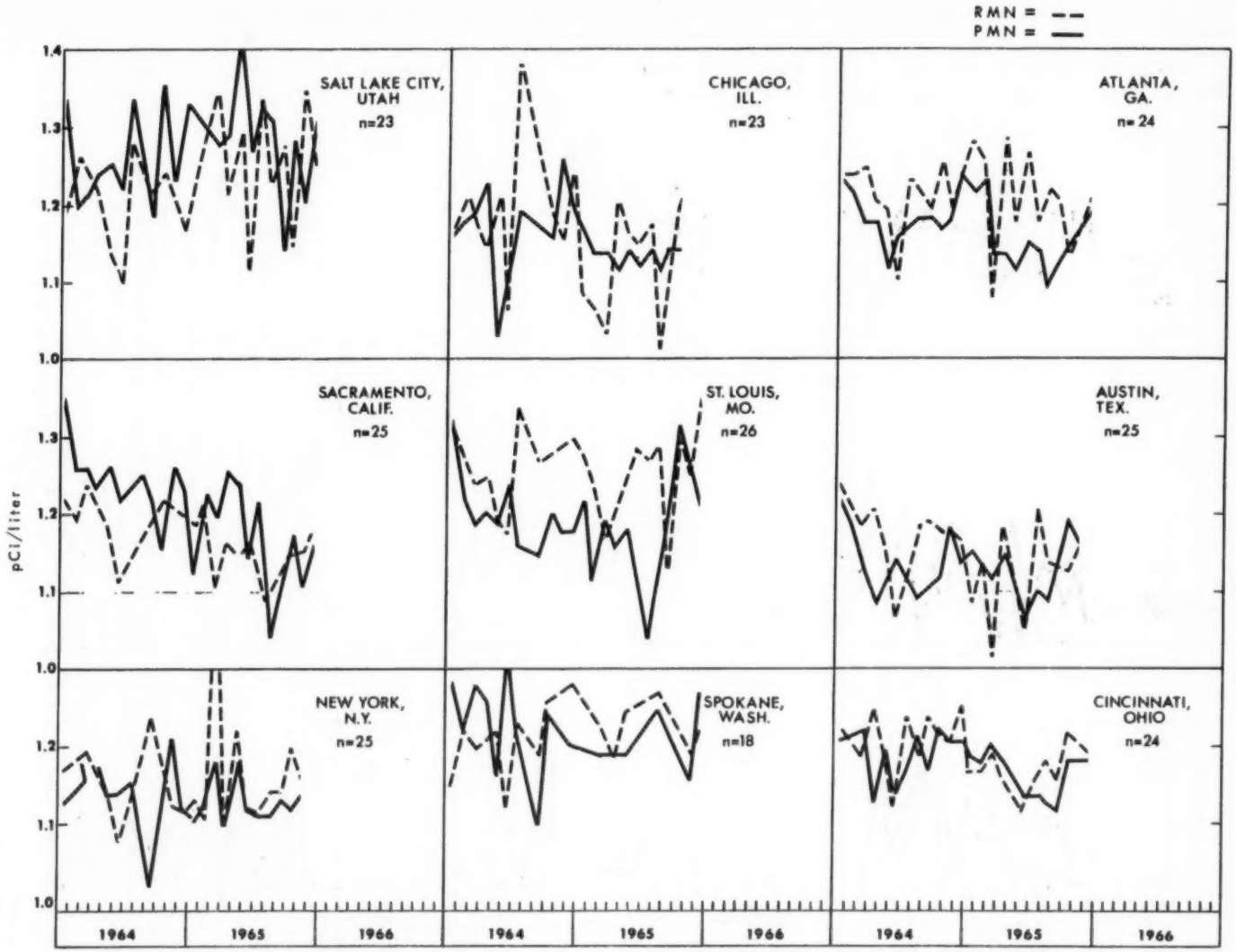

Figure 4. Calcium data corrected for laboratory effects[a] n=number of paired RMN–PMN samples
[a]Unadjusted data given in Appendix 1

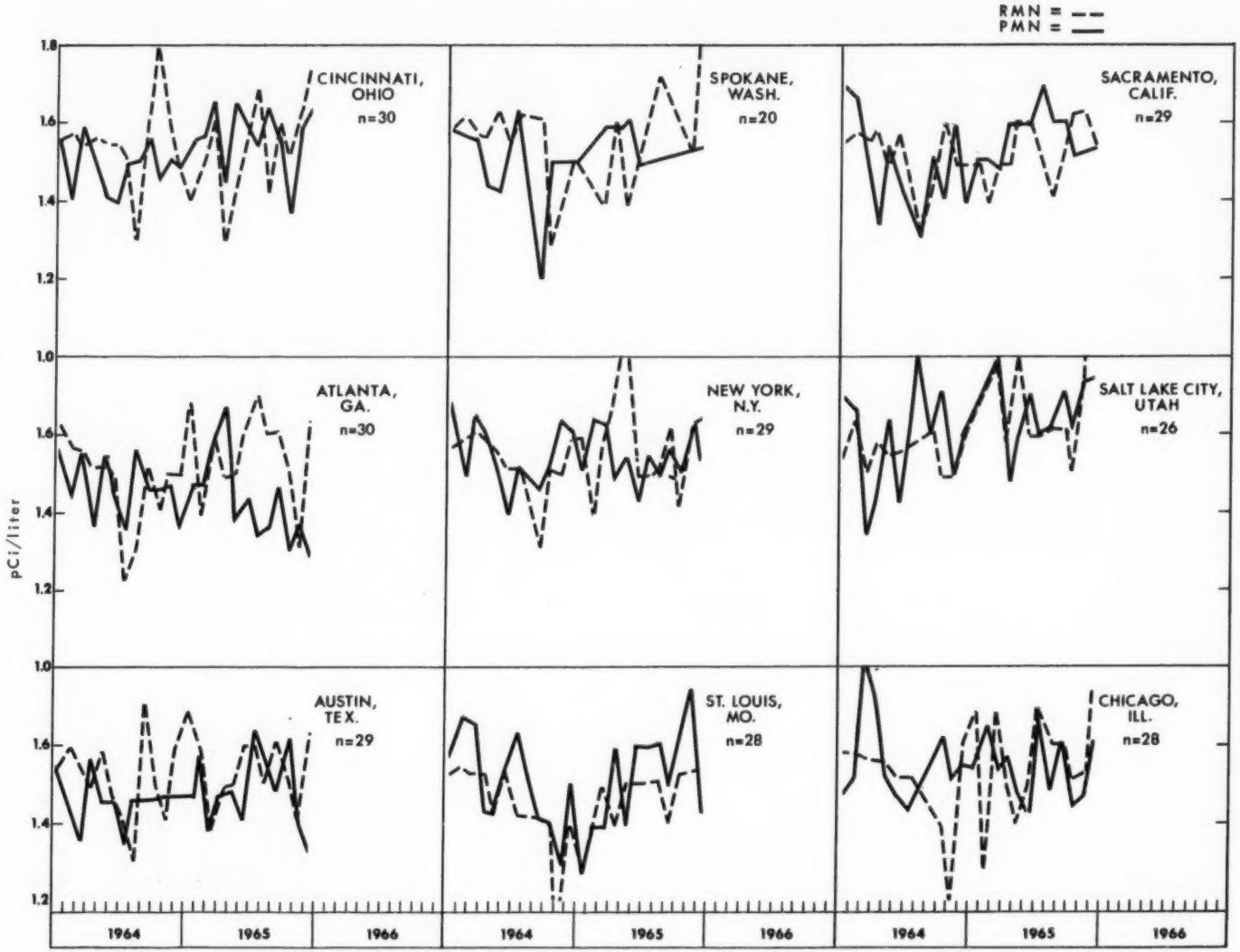

Figure 5. Potassium data corrected for laboratory effects[a] n=number of paired RMN–PMN samples
[a]Unadjusted data given in Appendix 1

tory analytical errors and sampling errors are greater than changes in the concentration levels. Similar results were observed for potassium with evidence of some correlation existing in St. Louis, Atlanta, and Chicago.

Conclusions

At four stations, where results obtained from the two milk sampling programs were similar, as is evidenced by the lack of significant differences in the mean concentrations (table 2) and the higher correlations in table 3 for strontium–90 and cesium–137, a greater degree of geographical overlap (figure 1) was found between the RMN and PMN milksheds than among the other stations. For these four cities, Salt Lake City, Sacramento, Austin, and Spokane, the raw milk sample is probably more representative of the PMN sample than for the other cities.

At two other stations, Cincinnati and Chicago, evidence was also found of correlation between the networks for cesium–137 and strontium–90 and a lack of significant differences in the paired t-tests for the mean concentrations of the elements and radionuclides studied. However, as can be seen in figure 1, these stations have little milkshed overlap. A plausible explanation of this apparent paradox lies in the relationship of farming practices, soil fertility, and rainfall between the RMN and PMN counties. Olsen (*8*) shows that these RMN milksheds normally have cows on pasture from May 1 to October 1, and that these dates can be extended to the PMN milksheds with the exception that the dates extend from April 1 to October 15 and May 15 to September 15 for Cincinnati and Chicago, respectively. Rainfall over this entire five-State area is fairly uniform and a survey of the farms at each milkshed that participate in the RMN shows a high degree of similarity as far as farming practices are concerned. Hence, it seems reasonable that each RMN milkshed is representative of the greater PMN milkshed due to the homogeneity of the important factors. Therefore, on this basis, it is not unreasonable to expect to see similarity in the levels of the elements and radionuclides studied.

In New York City, St. Louis, and Atlanta, where there was evidence of significant differences in the mean concentrations of various radionuclides and elements, the RMN and PMN milksheds had in common an extremely small geographical area. In New York City and St. Louis, the RMN sample was representative of only one out of 30 and one out of 26 dairies, respectively; and in Atlanta, one out of 4 dairies.

No attempt was made to do an internetwork comparison of the milk concentrations of iodine–131, barium–140, and strontium–89 because of the extremely low levels present during the period of this study.

Acknowledgment

The author expresses his appreciation to Mr. Loren Zelsman of the Standards and Intelligence Branch staff, National Center for Radiological Health, for his help in reducing and analyzing the data.

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Appendix I

Discussion and tabulation of findings for the Raw Milk Network, January 1963–December 1966

The values for all monthly samples collected in the Raw Milk Sampling Program from January 1963 through December 1966 are summarized in tables 4 through 10 for iodine–131, barium–140, strontium–89, strontium–90, cesium–137, calcium and potassium, respectively. A tabulation for the period 1957–1963 has been published earlier (*1*).

During 1963 there was a rapid decline in values for the short-lived radionuclides. However, by 1966, a decline in nearly all radionuclides was observed with only seasonal variations and slight effects due to the limited atmospheric tests in 1964.

From 1963–1966, the monthly average for iodine–131 at most stations was low or at the

Table 4. Concentrations of iodine–131 in raw milk, January 1963–December 1966

Month	Concentrations (pCi/liter)								
	New York City	Atlanta	Chicago	Cincinnati	St. Louis	Austin	Salt Lake City	Sacramento	Spokane
1963									
January	<10	15	<10	<10	20	40	<10	<10	<10
February	<10	10	<10	<10	<10	<10	<10	<10	<10
March	<10	<10	<10	<10	<10	<10	15	<10	10
(a)									
1965									
June	<10	<10	<10	50	<10	<10	<10	<10	<10
July	<10	<10	<10	<10	<10	<10	30	<10	—
August	<10	<10	<10	<10	<10	<10	<10	<10	<10
September	<10	20	<10	<10	<10	<10	10	10	—
(a)									
1966									
May	<10	<10	<10	<10	<10	<10	<10	<10	10
June	<10	20	20	<10	—	<10	10	<10	<10
July	<10	30	<10	<10	<10	—	<10	<10	<10
August	<10	<10	<10	<10	10	—	<10	<10	<10
September	<10	<10	<10	—	—	<10	<10	<10	<10
October	<10	<10	<10	<10	—	<10	<10	<10	<10
November	<10	<10	<10	<10	—	—	—	<10	<10
December	<10	<10	<10	<10	—	<10	—	<10	<10

[a] All intermediate data were <10 pCi/liter.

Table 5. Concentrations of barium–140 in raw milk, January 1963–December 1966

Month	Concentrations (pCi/liter)								
	New York City	Atlanta	Chicago	Cincinnati	St. Louis	Austin	Salt Lake City	Sacramento	Spokane
1963									
January	<10	10	<10	<10	<10	<10	<10	<10	<10
(a)									
1966									
June	<10	20	<10	<10	—	<10	<10	<10	<10
(a)									
December	<10	<10	<10	<10	—	<10	—	<10	<10

[a] All intermediate data were <10 pCi/liter.

nondetectable level. During the above mentioned period there were only 14 reports of detectable iodine–131. Data for barium–140 are similar to that for iodine–131. From 1963–1966 with the exception of two analyses, all concentrations of barium–140 were nondetectable.

During 1963, maximum concentrations of strontium–89 rose to nearly the same values in some locations as those recorded for 1957–1959 (*1*). During 1964–1966, concentrations were very low or nondetectable with only one significant value of 45 pCi/liter. Peak values are usually reached during the spring and summer months.

During 1963–1966, strontium–90 maximum and minimum values were considerably higher than were those for 1957–1961 (*1*), with a

Table 6. Concentrations of strontium–89 in raw milk, January 1963–December 1966

Month	Concentrations (pCi/liter)								
	New York City	Atlanta	Chicago	Cincinnati	St. Louis	Austin	Salt Lake City	Sacramento	Spokane
1963									
January	<5	95	<5	10	90	70	<5	10	<5
February	<5	65	<5	<5	75	35	25	25	<5
March	<5	80	<5	5	130	30	<5	30	<5
April	<5	95	10	80	180	45	<5	180	<5
May	30	255	25	80	170	65	<5	135	110
June	80	165	95	110	240	40	160	50	—
July	80	215	35	75	115	20	95	5	90
August	60	45	20	30	50	5	20	5	40
September	25	35	10	15	35	<5	15	<5	—
October	<5	<5	<5	<5	10	<5	<5	<5	15
November	10	<5	<5	5	5	<5	<5	<5	<5
December	<5	<5	<5	<5	<5	<5	<5	<5	<5
1964									
January	<5	<5	<5	<5	<5	<5	<5	<5	<5
February	<5	<5	<5	<5	<5	<5	<5	<5	<5
March	<5	<5	<5	<5	<5	<5	<5	<5	<5
April	<5	<5	<5	<5	<5	<5	<5	<5	<5
May	<5	<5	<5	<5	<5	<5	<5	<5	<5
June	<5	<5	<5	<5	<5	<5	<5	<5	<5
July	5	<5	<5	<5	5	<5	5	—	<5
August	<5	<5	<5	<5	<5	5	<5	<5	—
September	<5	<5	10	<5	<5	<5	<5	<5	<5
October	<5	<5	<5	<5	10	<5	<5	<5	5
November	5	<5	<5	<5	5	<5	<5	<5	—
December	<5	<5	<5	<5	10	<5	<5	<5	<5
1965									
January	<5	<5	<5	<5	5	<5	—	<5	—
February	<5	<5	<5	<5	<5	<5	<5	<5	—
March	<5	<5	<5	<5	<5	<5	<5	<5	<5
April	<5	<5	<5	<5	<5	<5	<5	<5	<5
May	5	<5	<5	<5	<5	<5	<5	<5	<5
June	<5	<5	<5	<5	25	<5	<5	<5	—
July	<5	<5	<5	<5	<5	<5	<5	<5	—
August	15	20	<5	<5	5	5	<5	<5	5
September	<5	<5	5	<5	<5	<5	<5	<5	—
October	5	<5	<5	<5	5	<5	5	<5	—
November	<5	<5	<5	<5	<5	<5	5	<5	<5
December	<5	<5	5	5	<5	<5	5	<5	<5
1966									
January	<5	<5	<5	<5	<5	<5	<5	<5	<5
February	<5	<5	<5	<5	<5	<5	<5	<5	—
March	<5	<5	<5	<5	<5	<5	<5	<5	<5
April	<5	<5	<5	<5	<5	—	<5	<5	—
May	<5	<5	<5	<5	<5	<5	<5	<5	<5
June	10	<5	<5	<5	10	10	<5	<5	<5
July	5	<5	<5	<5	45	—	5	<5	<5
August	<5	<5	<5	<5	<5	—	<5	<5	<5
September	<5	<5	<5	<5	—	<5	<5	<5	<5
October	<5	<5	<5	<5	—	<5	<5	<5	<5
November	<5	<5	<5	<5	—	—	—	<5	<5
December	—	—	—	—	—	—	—	—	<5

maximum value of 68 pCi/liter being reached in the spring of 1964.

Cesium–137 concentration trends in raw milk were similar to those for strontium–90 for the same period. During 1963–1964, concentrations of cesium–137 reached their highest values, peaking at 390 pCi/liter in the summer of 1963; declining again during 1965–1966.

Calcium and potassium measurements were rather constant during the years 1963–1966. Fluctuations in calcium and potassium data are generally ascribed to laboratory variations, as opposed to actual variations in milk concentrations.

Table 7. Concentrations of strontium–90 in raw milk, January 1963–December 1966

Month	Concentrations (pCi/liter)								
	New York City	Atlanta	Chicago	Cincinnati	St. Louis	Austin	Salt Lake City	Sacramento	Spokane
1963									
January	14	23	13	17	29	7	12	5	17
February	18	19	10	13	28	8	12	4	15
March	11	16	10	14	27	7	10	10	13
April	11	25	9	21	46	10	8	24	11
May	14	48	14	20	48	13	12	23	27
June	25	42	27	27	53	9	32	15	—
July	36	55	24	25	51	7	33	12	27
August	30	37	24	30	55	8	22	10	20
September	27	30	23	21	44	8	16	8	—
October	32	31	22	28	46	8	22	11	31
November	28	31	29	32	53	7	26	12	32
December	24	38	23	30	46	7	31	11	36
1964									
January	27	35	23	24	44	13	38	11	22
February	24	38	22	30	51	10	34	12	25
March	25	43	22	27	50	15	28	16	22
April	25	55	23	33	68	10	26	12	22
May	26	59	27	33	56	11	23	11	28
June	23	37	24	32	61	10	17	13	28
July	28	38	18	27	57	6	20	—	25
August	18	34	16	17	32	9	11	6	—
September	4	33	16	20	35	6	9	6	21
October	19	29	19	10	30	5	15	6	22
November	18	35	21	24	38	7	20	8	—
December	15	34	20	21	33	7	18	6	23
1965									
January	16	33	20	20	42	6	—	5	—
February	18	34	21	21	43	8	21	8	—
March	26	33	21	18	24	10	32	9	23
April	17	32	18	24	56	13	9	14	24
May	15	34	24	8	33	5	8	7	30
June	19	25	19	17	47	10	14	12	—
July	20	25	13	15	31	10	20	6	—
August	13	23	15	17	11	6	14	6	22
September	14	25	15	11	38	6	14	8	—
October	11	24	16	14	34	6	12	4	—
November	16	29	17	21	13	4	14	9	16
December	14	29	15	11	32	4	9	4	14
1966									
January	15	25	15	15	37	7	8	5	14
February	13	25	16	17	34	6	6	4	—
March	14	22	15	15	37	7	13	7	14
April	10	22	14	17	54	—	10	5	—
May	11	29	22	25	61	7	8	7	18
June	17	30	21	3	31	5	10	9	20
July	14	22	12	18	47	—	10	19	16
August	13	23	9	15	39	—	7	5	11
September	10	18	11	14	—	3	6	5	12
October	13	25	13	14	—	4	5	3	10
November	12	21	9	19	—	—	—	4	13
December	—	—	—	—	—	—	—	—	14

Table 8. Concentration of cesium-137 in raw milk, January 1963–December 1966

Month	Concentrations (pCi/liter)								
	New York City	Atlanta	Chicago	Cincinnati	St. Louis	Austin	Salt Lake City	Sacramento	Spokane
1963									
January	75	85	75	75	100	30	105	25	85
February	65	90	75	60	100	30	80	25	90
March	70	95	75	65	110	30	90	45	90
April	60	100	70	65	115	60	55	120	75
May	75	265	75	70	210	70	80	145	120
June	140	245	185	105	295	55	310	95	—
July	170	390	130	110	200	50	215	60	185
August	185	185	135	95	165	35	140	50	145
September	145	130	100	65	150	35	125	85	—
October	140	120	95	60	155	45	155	55	55
November	170	125	130	110	180	45	155	75	180
December	160	145	150	110	190	45	245	70	205
1964									
January	180	175	155	130	220	65	225	65	155
February	155	170	155	125	185	50	240	70	175
March	160	195	155	120	200	50	230	80	150
April	170	185	155	115	205	40	220	55	150
May	145	255	135	80	180	60	155	55	165
June	150	80	145	80	205	45	145	70	145
July	115	115	115	70	110	35	75	—	125
August	90	95	80	40	80	45	90	30	—
September	70	85	70	35	70	75	30	30	125
October	70	80	70	40	75	25	75	20	95
November	60	95	10	55	90	30	100	35	—
December	70	80	50	55	100	105	75	35	100
1965									
January	50	55	65	75	85	10	—	35	—
February	75	85	70	70	95	15	90	20	—
March	65	90	80	50	100	30	165	35	70
April	80	60	105	55	85	50	110	35	120
May	70	65	75	35	45	25	50	20	95
June	40	45	45	30	50	20	55	20	80
July	35	30	20	20	45	20	70	20	—
August	30	40	30	20	35	15	45	15	60
September	30	40	45	25	35	10	40	20	—
October	15	40	30	15	50	<5	45	10	—
November	30	25	20	20	30	<5	40	15	40
December	50	55	40	60	50	15	45	30	50
1966									
January	20	35	35	20	30	15	25	15	40
February	35	50	45	15	35	20	40	25	—
March	15	55	40	30	45	20	35	20	35
April	40	40	45	30	40	—	35	20	—
May	40	30	45	25	30	15	30	25	45
June	25	45	40	10	25	10	35	15	45
July	15	40	30	20	35	—	20	20	30
August	20	40	15	10	15	—	20	15	20
September	15	40	15	20	—	5	20	5	50
October	10	20	5	5	—	5	10	<5	25
November	15	20	15	20	—	10	—	10	10
December	10	25	15	10	—	—	—	10	25

Table 9. Concentrations of calcium in raw milk (g/liter) January 1963–December 1966[a]

Month	New York City	Atlanta	Chicago	Cincinnati	St. Louis	Austin	Salt Lake City	Sacramento	Spokane
1963									
January	1.05	1.13	1.09	1.13	1.20	1.09	1.12	1.12	1.09
February	1.08	1.16	1.09	1.13	1.19	1.11	1.14	1.14	1.17
March	1.07	1.14	1.12	1.14	1.20	1.08	1.09	1.10	1.14
April	1.05	1.11	1.08	1.09	1.18	1.06	1.07	1.11	1.10
May	1.14	1.19	1.10	1.10	1.22	1.06	1.13	1.14	1.08
June	1.11	1.17	1.17	1.17	1.30	1.09	1.16	1.14	—
July	1.07	1.16	1.20	1.13	1.20	1.07	1.11	1.13	1.10
August	1.04	1.08	1.09	1.14	1.22	1.11	1.13	1.14	1.15
September	1.12	1.13	1.12	1.14	1.26	1.13	1.14	1.15	—
October	1.15	1.14	1.13	1.17	1.22	1.14	1.12	1.13	1.14
November	1.14	1.19	1.17	1.19	1.12	1.17	1.14	1.16	1.17
December	1.14	1.20	1.14	1.21	1.23	1.16	1.16	1.19	1.22
1964									
January	1.15	1.21	1.15	1.20	1.28	1.21	1.17	1.20	1.13
February	1.16	1.22	1.19	1.19	1.26	1.19	1.24	1.18	1.20
March	1.18	1.24	1.17	1.18	1.23	1.18	1.23	1.23	1.19
April	1.17	1.21	1.15	1.25	1.25	1.21	1.22	1.24	1.21
May	1.15	1.21	1.22	1.20	1.21	1.17	1.15	1.20	1.23
June	1.09	1.12	1.07	1.19	1.19	1.08	1.12	1.13	1.14

Table 9. Concentrations of calcium in raw milk (g/liter) January 1963–December 1966[a]—Continued.

Month	New York City	Atlanta	Chicago	St. Louis	Cincinatti	Austin	Salt Lake City	Sacramento	Spokane
1964									
July	1.14	1.26	1.52	1.26	1.36	1.14	1.30	——	1.25
August	1.15	1.25	1.23	1.22	1.26	1.21	1.22	1.20	——
September	1.28	1.23	1.30	1.28	1.31	1.22	1.25	1.22	1.22
October	1.22	1.30	1.24	1.26	1.32	1.22	1.28	1.26	1.30
November	1.17	1.25	1.20	1.26	1.34	1.23	1.47	1.26	——
December	1.17	1.29	1.29	1.30	1.36	1.22	1.42	1.25	1.34
1965									
January	1.18	1.34	1.14	1.23	1.34	1.14	——	1.25	——
February	1.17	1.32	1.12	1.23	1.30	1.20	1.36	1.27	——
March	1.44	1.14	1.10	1.26	1.23	1.08	1.43	1.17	1.30
April	1.16	1.36	1.28	1.23	1.26	1.26	1.29	1.23	1.26
May	1.30	1.26	1.24	——	1.32	1.17	1.38	1.22	1.32
June	1.20	1.35	1.22	1.19	1.36	1.13	1.19	1.23	——
July	1.20	1.26	1.25	1.24	1.36	1.29	1.43	1.28	——
August	1.22	1.30	1.09	1.26	1.38	1.22	1.31	1.18	1.36
September	1.22	1.30	1.21	1.24	1.21	——	1.37	——	——
October	1.29	1.22	1.30	1.31	1.39	1.21	1.23	1.23	——
November	1.25	1.31	1.23	1.24	1.35	1.25	1.45	1.24	1.28
December	1.35	1.30	1.31	1.28	1.45	1.31	1.34	1.27	1.31
1966									
January	1.37	1.33	1.21	1.31	1.34	1.18	1.30	1.54	1.33
February	1.22	1.27	1.27	1.19	1.12	1.17	1.30	1.22	——
March	1.19	1.28	1.19	1.19	1.22	1.10	1.38	1.28	1.39

[a] Calcium analysis discontinued after March 1966.

Table 10. Concentrations of potassium in raw milk, January 1963–December 1966

Month	Concentrations (g/liter)								
	New York City	Atlanta	Chicago	Cincinnati	St. Louis	Austin	Salt Lake City	Sacramento	Spokane
1963									
January	1.5	1.5	1.6	1.5	1.4	1.5	1.5	1.5	1.5
February	1.5	1.4	1.6	1.5	1.5	1.5	1.6	1.5	1.5
March	1.5	1.4	1.6	1.5	1.5	1.5	1.5	1.5	1.5
April	1.6	1.4	1.5	1.5	1.5	1.5	1.5	1.4	1.5
May	1.5	1.5	1.5	1.5	1.5	1.5	1.6	1.5	1.5
June	1.7	1.7	1.6	1.6	1.6	1.6	1.6	1.7	——
July	——	——	——	——	——	——	——	——	——
August	——	——	——	——	——	——	——	——	——
September	1.6	1.5	1.6	1.5	1.6	1.6	1.5	1.6	——
October	1.6	1.4	1.5	1.5	1.5	1.5	1.5	1.6	1.5
November	1.6	1.4	1.5	1.5	1.4	1.5	1.5	1.6	1.6
December	1.5	1.5	1.4	1.5	1.5	1.5	1.5	1.4	1.5
1964									
January	1.5	1.5	1.5	1.5	1.4	1.5	1.5	1.5	1.5
Februar	1.5	1.5	1.5	1.5	1.5	1.5	1.6	1.5	1.5
March	1.6	1.5	1.5	1.5	1.5	1.5	1.4	1.5	1.5
April	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
May	1.5	1.5	1.5	1.5	1.4	1.5	1.5	1.5	1.6
June	1.5	1.5	1.5	1.5	1.5	1.4	1.5	1.5	1.5
July	1.5	1.2	1.5	1.5	1.4	1.4	0.9	——	1.6
August	1.2	1.3	1.2	1.3	1.4	1.3	1.2	1.3	——
September	1.3	1.5	1.5	1.6	1.4	1.7	1.6	1.4	1.6
October	1.5	1.4	1.4	1.8	1.4	1.5	1.5	1.6	1.3
November	1.5	1.5	1.2	1.6	1.1	1.4	1.5	1.5	——
December	1.6	1.5	1.6	1.5	1.4	1.6	1.6	1.5	1.5
1965									
January	1.6	1.7	1.7	1.4	1.3	1.7	——	1.5	——
February	1.4	1.4	1.3	1.5	1.4	1.6	1.6	1.4	——
March	1.6	1.6	1.7	1.6	1.5	1.4	1.8	1.5	1.4
April	1.7	1.5	1.5	1.3	1.4	1.5	1.6	1.5	1.6
May	1.9	1.5	1.4	1.4	1.5	1.5	1.8	1.6	1.4
June	1.5	1.6	1.5	1.5	1.5	1.6	1.6	1.6	1.5
July	1.5	1.7	1.7	1.7	1.5	1.6	1.6	1.5	——
August	1.5	1.6	1.6	1.4	1.5	1.5	1.6	1.4	1.7
September	1.6	1.6	1.6	1.6	1.4	1.6	1.6	1.5	——
October	1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.6	——
November	1.6	1.3	1.5	1.6	1.5	1.4	1.7	1.6	1.5
December	1.6	1.6	1.7	1.7	1.5	1.6	2.0	1.5	1.8
1966									
January	1.5	1.6	1.6	1.5	1.4	1.5	1.5	1.5	1.6
February	1.4	1.2	1.5	1.3	1.2	1.5	1.6	1.3	——
March	1.3	1.0	1.3	1.2	1.0	1.2	1.6	1.4	1.4
April	1.4	1.2	1.3	1.2	1.1	——	1.4	1.1	——
May	1.4	1.1	1.3	1.2	1.2	1.3	1.3	1.3	1.3
June	1.3	1.4	1.3	1.4	1.3	1.2	1.4	1.4	1.4
July	1.4	1.4	1.2	1.5	1.3	——	1.7	1.2	1.4
August	1.4	1.3	1.3	1.4	1.3	——	1.4	1.4	1.5
September	1.3	1.4	1.3	1.4	——	1.3	1.4	1.3	1.4
October	1.3	1.4	1.2	1.4	——	1.3	1.4	1.4	1.2
November	1.3	1.3	1.2	1.1	——	——	——	1.2	1.3
December	1.3	1.4	1.3	1.3	——	1.4	——	1.2	1.3

SECTION I. MILK AND FOOD

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Federal and State agencies are involved in efforts to monitor continuously the dietary intake of radionuclides. The most direct measure of radionuclide intake would be obtained by radioanalysis of the total diet. Difficulties in obtaining specific dietary data impede this approach. An alternate method entails the use of indicator foods to arrive at an estimate of the total dietary radionuclide intake.

Fresh milk is one such indicator food. It is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides which appear in the diet. It also is one of the major sources of dietary intake for the short-lived radionuclides. For these reasons, fresh milk is the single food item most often used in estimating the intake of selected radionuclides by the general population and/or specific population groups. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of fresh milk.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming continuous exposure from intake by the population at large (*1–3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the FRC Protective Action Guides (*4*) and by the International Commission on Radiological Protection (*5,6*).

Data from selected national, international, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

REFERENCES

(*1*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 13, 1960).

(*2*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1960).

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, protective action for strontium–89, strontium–90, and cesium–137, Report No. 7. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (July 1964).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1965).

(*5*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 2. Pergamon Press, New York, N.Y. (1959).

(*6*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 6. Pergamon Press, New York, N.Y. (1965).

National and International Milk Surveillance

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various national and international organizations routinely monitor radionuclide levels in milk. In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

Program	Period reported	Last presented
Radiostrontium in milk, HASL	January–December 1967	August 1968

1. Pasteurized Milk Network
May 1968

National Center for Radiological Health and *National Center for Urban and Industrial Health, PHS*

The Public Health Service's Pasteurized Milk Network (PMN) is designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 stations (figure 1) provides data on milk in every State, Washington, D. C., the Canal Zone, and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the January 1968 issue of *Radiological Health Data and Reports* (*1*). Reference should also be made to the February 1968 issue (*2*), in which several changes in the interpretation and reporting of data were introduced.

Table 1. Analytical errors associated with determinations of radionuclide concentrations in a milk sample

Nuclide	Concentration (pCi/liter)	Error [a] (pCi/liter)	Concentration (pCi/liter)	Error [a] (percent of concentration)
Strontium-89	<50	5	≥50	10
Strontium-90	<20	2	≥20	10
Iodine-131	<100	10	≥100	10
Cesium-137	<100	10	≥100	10
Barium-140	<100	10	≥100	10

[a] Two standard deviations.

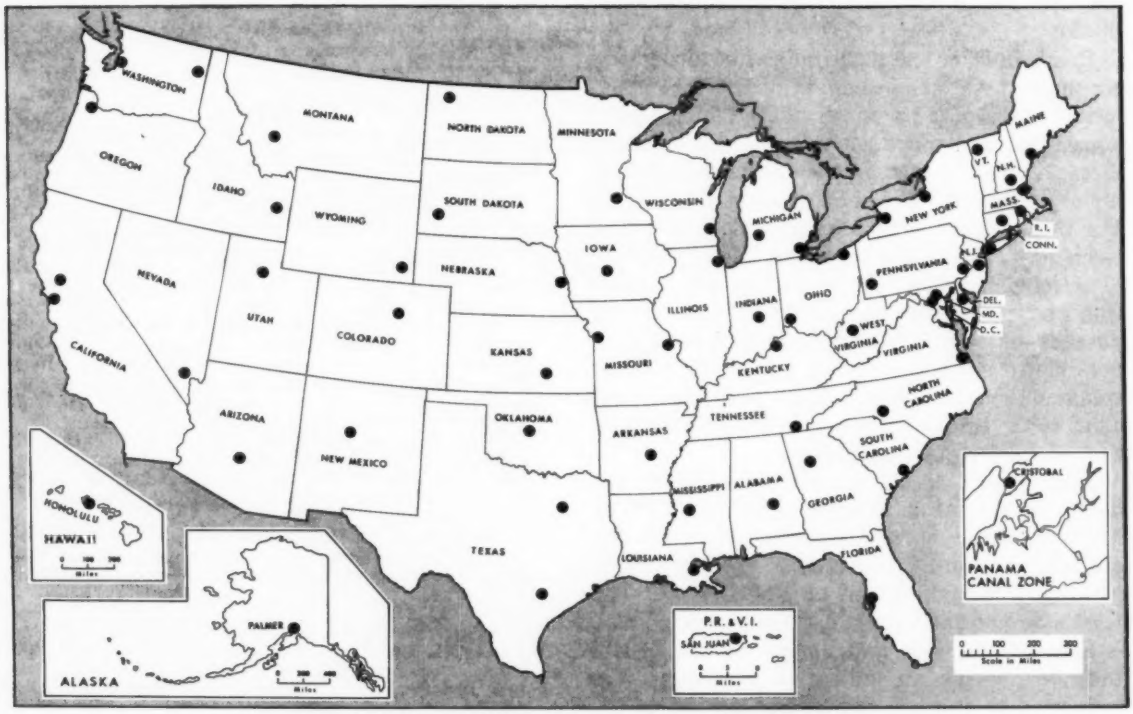

Figure 1. Pasteurized Milk Network sampling stations

Table 2. Average concentrations of radionuclides in milk for May 1968 and the 12-month period, June 1967 through May 1968

Sample location		Radionuclide concentrations [a] (pCi/liter)									
		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
		June 1967–May 1968	May 1968	June 1967–May 1968	May 1968	June 1967–May 1968	May 1968	June 1967–May 1968	May 1968	June 1967–May 1968	May 1968
Ala:	Montgomery	0	0	9	9	0	0	13	16	0	0
Alaska:	Palmer	0	0	6	6	0	0	16	8	1	0
Ariz:	Phoenix	0	0	1	0	0	0	2	3	0	0
Ark:	Little Rock	1	11	21	23	0	0	19	24	0	0
Calif:	Sacramento	0	0	3	3	0	0	6	5	1	0
	San Francisco	1	6	2	0	0	0	4	8	1	0
C. Z:	Cristobal	0	0	2	3	0	0	11	3	0	0
Colo:	Denver	1	0	5	3	0	0	7	8	0	0
Conn:	Hartford	NA	NA	9	10	0	0	13	14	0	0
Del:	Wilmington	NA	NA	11	11	0	0	9	17	0	0
D. C:	Washington	0	0	10	10	0	0	5	6	0	0
Fla:	Tampa	0	0	8	8	0	0	70	60	0	0
Ga:	Atlanta	0	0	15	16	0	0	21	19	0	0
Hawaii:	Honolulu	0	0	3	4	1	0	5	5	0	0
Idaho:	Idaho Falls	1	0	6	7	0	0	8	6	0	0
Ill:	Chicago	0	0	9	10	0	0	10	6	0	0
Ind:	Indianapolis	NA	NA	7	7	0	0	7	7	0	0
Iowa:	Des Moines	0	0	7	8	0	0	7	0	0	0
Kans:	Wichita	1	0	9	12	0	0	4	10	0	0
Ky:	Louisville	0	0	12	13	0	0	5	7	0	0
La:	New Orleans	0	0	22	21	0	0	24	25	0	0
Maine:	Portland	NA	NA	10	NA	0	0	31	30	0	0
Md:	Baltimore	0	0	10	9	0	0	5	3	0	0
Mass:	Boston	0	0	12	13	0	0	25	21	0	0
Mich:	Detroit	NA	NA	8	8	0	0	12	13	0	0
	Grand Rapids	NA	NA	10	12	0	0	15	11	0	0
Minn:	Minneapolis	0	0	11	10	0	0	12	7	0	0
Miss:	Jackson	0	0	17	17	0	0	14	18	0	0
Mo:	Kansas City	1	6	9	10	0	0	4	9	1	0
	St. Louis	1	0	9	10	0	0	6	3	0	0
Mont:	Helena	1	0	5	0	0	0	7	5	1	0
Nebr:	Omaha	1	0	8	8	0	0	5	8	0	0
Nev:	Las Vegas	0	0	2	2	0	0	4	0	0	0
N. H:	Manchester	NA	NA	13	14	0	0	35	29	0	0
N. J:	Trenton	NA	NA	10	9	0	0	10	17	0	0
N. Mex:	Albuquerque	0	0	2	3	0	0	2	0	0	0
N. Y:	Buffalo	NA	NA	8	9	0	0	11	16	0	0
	New York City	NA	NA	10	14	0	0	13	16	0	0
	Syracuse [b]	NA	NA	7	9	0	0	9	10	0	0
N. C:	Charlotte	0	0	16	14	1	0	13	11	0	0
N. Dak:	Minot	2	0	11	7	0	0	11	14	0	0
Ohio:	Cincinnati	NA	NA	9	12	0	0	6	9	0	0
	Cleveland	NA	NA	9	10	0	0	9	9	0	0
Okla:	Oklahoma City	0	0	10	12	0	0	4	7	0	0
Ore:	Portland	1	6	7	6	0	0	15	24	0	3
Pa:	Philadelphia	NA	NA	8	11	0	0	8	7	0	0
	Pittsburgh	NA	NA	12	11	0	0	14	15	0	0
P. R:	San Juan	0	0	5	4	0	0	11	2	0	0
R. I:	Providence	NA	NA	11	11	0	0	19	16	0	0
S. C:	Charleston	0	0	14	12	0	0	29	32	0	0
S. Dak:	Rapid City	1	0	11	9	0	0	10	10	0	0
Tenn:	Chattanooga	0	0	14	12	0	0	14	10	0	0
	Memphis	0	0	12	13	0	0	5	7	0	0
Tex:	Austin	0	0	4	3	0	0	4	2	0	0
	Dallas	0	NA	7	NA	0	0	5	5	0	0
Utah:	Salt Lake City	1	0	5	6	0	0	12	13	0	0
Va:	Norfolk	0	0	11	13	0	0	10	5	0	0
Vt:	Burlington	NA	NA	11	11	0	0	11	13	0	0
Wash:	Seattle	2	0	9	11	0	0	24	32	1	4
	Spokane	1	0	8	8	0	2	13	14	0	0
W. Va:	Charleston	0	0	11	15	0	0	4	0	0	0
Wisc:	Milwaukee	NA	NA	8	7	0	0	11	5	0	0
Wyo:	Laramie	0	NA	4	NA	0	0	6	12	0	0
Network monthly average		0	1	9	9	0	0	12	11	0	0

[a] See text for averaging procedure.
[b] 12-month averages represent only 9 months data.
NA no analysis.

Table 1 shows the approximate analytical errors (including counting error) associated with determinations of radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. Table 2 contains averages

for May 1968 and 12-month average for the period, June 1967 through May 1968. The 12-month average facilitates evaluations of population exposure with respect to the guidance provided by the Federal Radiation Council, which suggests average total daily intakes "averaged over periods of the order of a year," as an appropriate criterion (*3*). The average radionuclide concentrations are based on results obtained from samples collected weekly. Whenever weekly concentrations were less than or equal to the appropriate minimum detectable levels, zero was used for averaging purposes (*2*). At very low radionuclide concentrations this often results in averages lower than the minimum detectable concentration for a single sample, but any positive value reflects at least one weekly sample which was above the minimum detectable level. The minimum detectable concentration is defined as the measured concentration equal to the two-standard deviation analytical error. Accordingly, the minimum detectable concentrations in units of pCi/liter are: strontium–89, 5; strontium–90, 2; iodine–131, cesium–137, and barium–140, 10.

The average strontium–90 concentrations in pasteurized milk from selected cities are presented in figure 2.

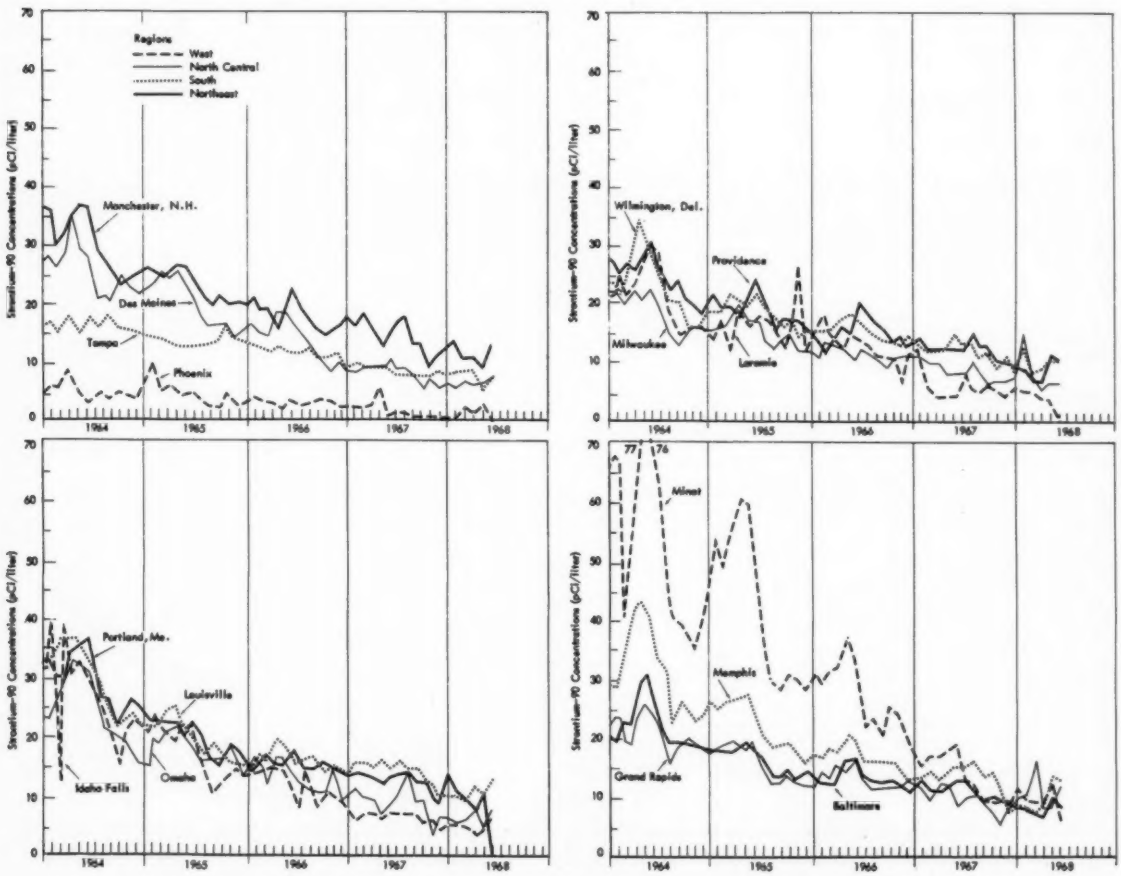

Figure 2. Strontium–90 concentrations in pasteurized milk, 1964–May 1968

2. Canadian Milk Network May 1968 [1]

Radiation Protection Division
Department of National Health and Welfare

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine–131, and monthly composites are analyzed for strontium–90, cesium–137, and stable calcium and potassium. The analytical procedures were outlined in the April 1968 issue of *Radiological Health Data and Reports* (*4*).

The May 1968 monthly average strontium–90, cesium–137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 3. Iodine–131 and strontium–89 concentrations were below minimum detectable levels.

[1] Prepared from June 1968 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 3. Stable elements and radionuclides in Canadian whole milk, May 1968

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.11	1.5	8.5	14
Edmonton	1.15	1.4	7.0	17
Ft. William	1.11	1.5	16.8	18
Fredericton	1.06	1.6	16.3	19
Halifax	1.11	1.5	12.0	22
Montreal	1.09	1.5	9.6	22
Ottawa	1.13	1.4	9.2	17
Quebec	1.07	1.4	12.0	32
Regina	1.11	1.5	7.4	11
St. John's, Nfld.	1.13	1.5	14.2	27
Saskatoon	1.11	1.4	9.2	19
Saulte Ste. Marie	1.07	1.6	15.5	25
Toronto	1.13	1.5	5.4	17
Vancouver	1.15	1.4	16.8	48
Windsor	1.15	1.5	4.5	16
Winnipeg	1.07	1.8	7.8	21
Average	1.11	1.5	10.8	21

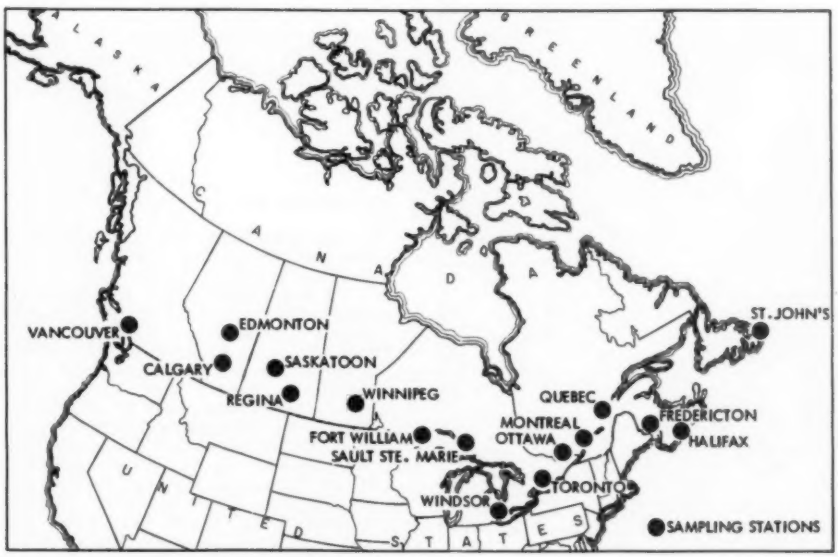

Figure 3. Canadian milk sampling stations

3. Pan American Milk Sampling Program May 1968

Pan American Health Organization and *U.S. Public Health Service*

The Pan American Health Organization (PAHO) in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1966 issue of *Radiological Health Data and Reports* (*5*).

Figure 4. Pan American Milk Sampling Program stations

Table 4 presents stable potassium, strontium–90 and cesium–137 monthly concentrations for May 1968.

Table 4. Stable element and radionuclide concentrations in Pan American milk,[a] May 1968

Sampling station		Number of samples	Potassium (g/liter)	Strontium-90 [b] (pCi/liter)	Cesium-137 [b] (pCi/liter)
Chile:	Santiago	4	1.63	0	0
Colombia:	Bogota	1	1.56	0	0
Ecuador:	Guayaquil	2	1.55	0	0
Jamaica:	Mandeville	4	1.52	5	65
Venezuela:	Caracas	4	1.51	0	0
Canal Zone:	Cristobal [c]	4	1.52	3	3
Puerto Rico:	San Juan	4	1.56	4	2

[a] All strontium-89 results were $\leq$ 5pCi/liter; iodine-131 and barium-140 results were all $\leq$ 10 pCi/liter.
[b] Strontium-90 single sample results $\leq$ 2 pCi/liter and cesium-137 single sample results $\leq$ 10 pCi/liter are reported as 0.
[c] For comparison, the radionuclide concentrations in Pasteurized Milk Network samples collected at Cristobal, Canal Zone, and San Juan, Puerto Rico, are presented.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE. Pasteurized Milk Network, September 1967. Radiol Health Data Rep 9:20–23 (January 1968).
(*2*) PUBLIC HEALTH SERVICE. Pasteurized Milk Network, October 1967. Radiol Health Data Rep 9:86–89 (February 1968).
(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1960).
(*4*) DEPARTMENT OF NATIONAL HEALTH AND WELFARE, RADIATION PROTECTION DIVISION. Canadian Milk Network, August 1966. Radiol Health Data Rep 7:702–703 (December 1966).
(*5*) PAN AMERICAN HEALTH ORGANIZATION and U.S. PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1966. Radiol Health Data Rep 7:704–705 (December 1966).

State Milk Surveillance Activities

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States now have comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

Figure 1 shows the States which report milk surveillance activities in *Radiological Health Data and Reports*. States having programs appearing in this issue are highlighted in the figure. Following is a summary of previously covered State programs, their reporting period, and the last issue in which they appeared.

State milk network	Period reported	Last presented
Colorado	January–March 1968	July 1968
Connecticut	January–March 1968	August 1968
Florida	January–March 1968	July 1968
Indiana	January–March 1968	August 1968
Iowa	January–March 1968	August 1968
Michigan	January–March 1968	August 1968
Minnesota	January–March 1968	August 1968
New York	January–March 1968	August 1968
Pennsylvania	January–March 1968	August 1968
Tennessee	January–March 1968	July 1968
Texas	January–March 1968	July 1968

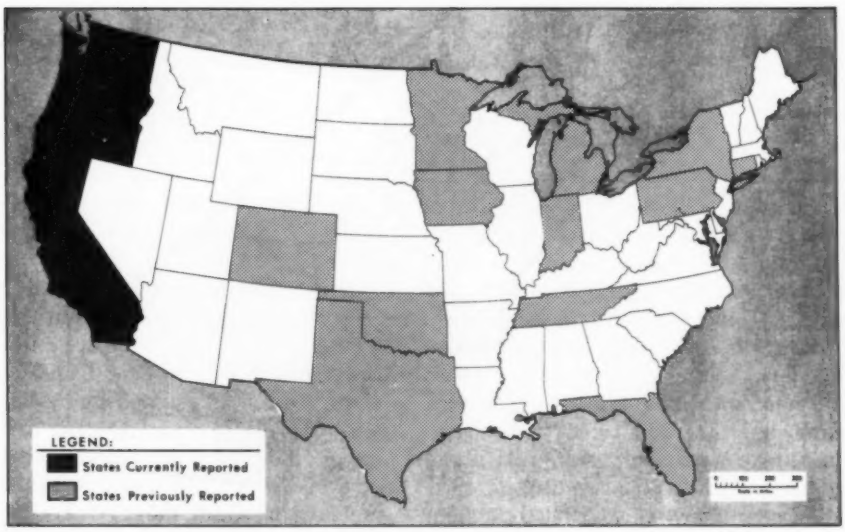

Figure 1. Reported State milk programs

1. California Milk Network January–March 1968

Division of Environmental Sanitation
State of California
Department of Public Health

Surveillance of specific radionuclides in milk is one phase of the California Department of Health program on radiation control. This milk monitoring function is conducted by the Department's Bureau of Radiological Health at 10 major milksheds (figure 2).

In January 1960, the eight original sampling locations were chosen by the State Department of Agriculture so as to be representative of milk consumed by a high percentage of the State's population. The Del Norte and Mendocino milksheds were added to the program in March 1962 and since that time, weekly, biweekly or monthly sampling of pasteurized milk has been conducted in 10 milkshed areas of the State. A description of the various California milksheds was presented earlier by Heslep and Cornish (*1*).

Strontium–89 and strontium–90 concentrations are determined radiochemically. Potassium–40, iodine–131, cesium–137, and barium–140 in whole fluid milk are determined by gamma-ray scintillation spectrometry. A detailed description of the analytical procedures was presented in an earlier report (*2*).

The monthly calcium, potassium and radionuclide concentrations in California pasteurized milk are given in table 1 for the period of January to March 1968. All iodine–131 concentrations remained below detectable levels of 10 pCi/liter during this period.

Network average strontium–90 and cesium–137 concentrations are presented graphically in figure 3.

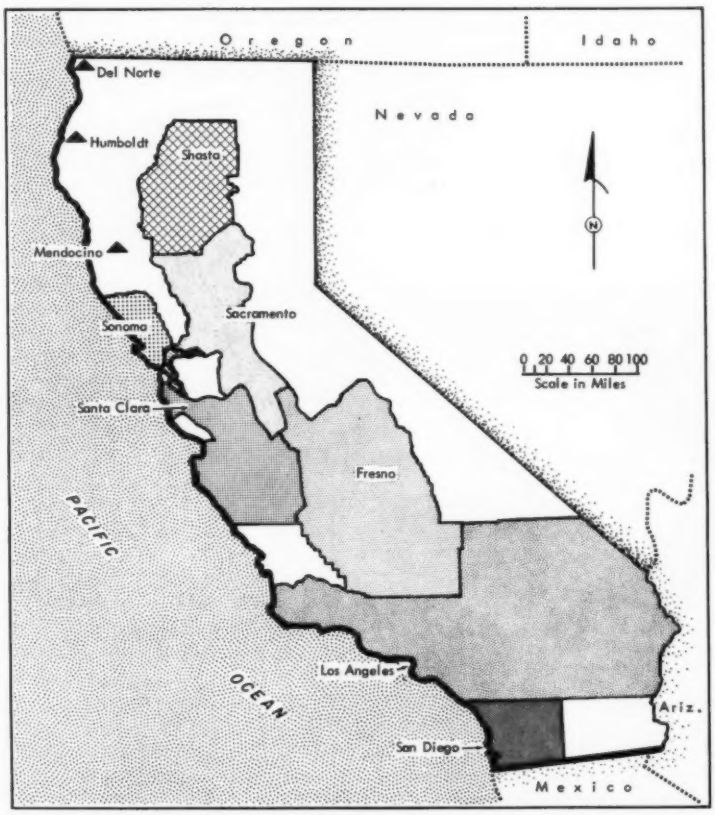

Figure 2. California milksheds

Table 1. Stable elements and radionuclides in California milk, January–March 1968

Sampling location	Calcium (g/liter)			Potassium (g/liter)			Strontium-89 (pCi/liter)			Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)			Barium-140 (pCi/liter)		
	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar
Del Norte	1.27	NS	1.06	1.5	NS	1.4	18	NS	21	19	NS	20	24	NS	21	37	NS	21
Fresno	1.10	1.10	1.10	1.5	1.5	1.6	ND	ND	ND	ND	ND	ND	18	11	8	ND	18	13
Humboldt	1.16	1.15	1.18	1.5	1.5	1.4	10	11	ND	6	2	3	12	ND	5	34	ND	48
Los Angeles	1.11	1.12	1.01	1.6	1.5	1.6	ND	ND	ND	ND	ND	ND	ND	12	11	ND	ND	ND
Mendocino	1.13	1.33	1.14	1.6	1.5	1.7	3	ND	3	4	3	ND	ND	ND	ND	30	20	ND
Sacramento	1.21	1.17	1.21	1.6	1.6	1.5	ND	ND	ND	2	2	2	ND	ND	ND	ND	ND	ND
San Diego	1.09	1.13	1.07	1.5	1.5	1.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	18	16
Santa Clara	1.19	1.44	1.20	1.8	1.6	1.7	ND	ND	ND	ND	3	ND	ND	ND	ND	ND	ND	ND
Shasta	1.13	0.94	1.04	1.4	1.5	1.4	ND	ND	ND	5	3	3	ND	ND	ND	ND	ND	28
Sonoma	1.14	1.24	1.10	1.6	1.6	1.6	ND	3	ND	4	2	2	ND	ND	ND	ND	26	ND

NS, no sample collected.
ND, nondetectable.
Minimum detectable levels: strontium-89—2.5 pCi/liter; strontium-90—1.5 pCi/liter; iodine-131—7 pCi/liter; cesium-137—7 pCi/liter; barium-140—7 pCi/liter.

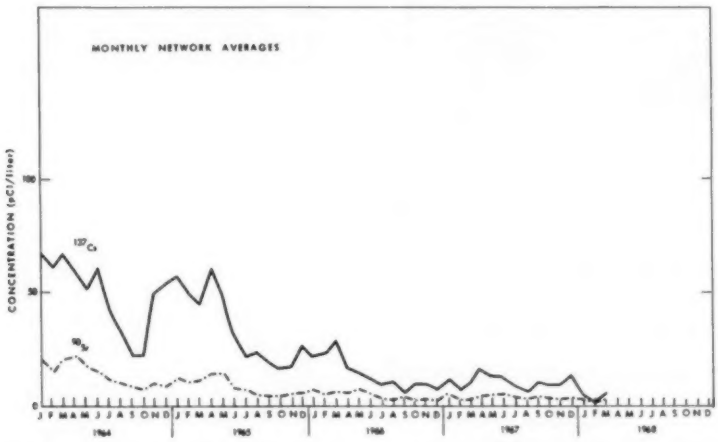
MONTHLY NETWORK AVERAGES
CONCENTRATION (pCi/liter)
100
50
0
137Cs
90Sr
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1964
1965
1966
1967
1968

Figure 3. Radionuclide concentrations in California milk, 1964–March 1968

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
March 1968	October–December 1967
July–September 1967	June 1968

2. Oregon Milk Network January–March 1968

Division of Sanitation and Engineering
Oregon State Board of Health

The Oregon State Board of Health has monitored radionuclide concentrations in milk since March 1962. As part of this program routine milk samples are collected at seven major production areas (figure 4), which supply 90 percent of the milk distributed in Oregon. Currently, pasteurized milk samples are collected monthly by the Oregon Department of Agriculture, except in the Portland area where weekly samples are collected by the city of Portland. The milk sampling frequency is accelerated to a weekly basis in areas where iodine–131 concentrations exceed 100 pCi/liter, or when cesium–137 concentrations exceed 500 pCi/liter. Strontium–90 analyses are performed on a bimonthly basis, but may be done monthly when significant increases are observed.

Strontium–90 concentrations are determined using an ion-exchange analytical procedure (*3*). Iodine–131, cesium–137, and barium–140

concentrations are determined by gamma-ray scintillation spectrometry (*4*).

Table 2 gives the strontium–90 and cesium–137 concentrations in pasteurized milk from January through March 1968. These data are presented graphically in figure 5. Iodine–131 and barium–140 concentrations remained below minimum detectable levels of 15 pCi/liter for all samples which were collected in January through March 1968.

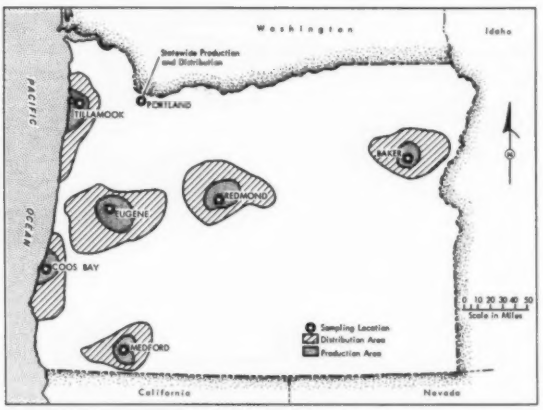

Figure 4. Oregon milk production and distribution areas

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–September 1967	March 1968
October–December 1967	June 1968

Table 2. Radionuclide concentrations in Oregon pasteurized milk, January–March 1968

Location	Sampling frequency	Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
		Jan	Feb	Mar	Jan	Feb	Mar
Baker	M	7	NA	4	<15	24	<15
Coos Bay	M	7	NA	8	20	33	<15
Eugene	M	4	NA	4	21	18	<15
Medford	M	4	NA	3	19	36	<15
Portland composite	W	14	NA	4	18	19	16
Portland local	W	4	NA	9	20	19	16
Redmond	M	8	NA	4	<15	32	20
Tillamook	M	NA	NA	10	<15	24	<15

Key to symbols: M, sampled monthly.
W, sampled weekly.
NA, no analysis.

MONTHLY NETWORK AVERAGES
CONCENTRATION (pCi/liter)
137Cs
90Sr
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1964
1965
1966
1967
1968

Figure 5. Radionuclide concentrations in Oregon milk network, 1964–March 1968

3. Washington Milk Network January–March 1968

Office of Air Quality Control
State of Washington Department of Health

The Washington State Department of Health initiated a surveillance program for radioactivity in raw milk in December 1962. The collection points shown in figure 6 were selected to provide samples representative of varying climatological conditions within the State's two major milksheds. In addition to the eight milk sampling locations in Washington, milk is sampled from Northwest Idaho (Sandpoint), as this area forms a part of the Spokane milkshed. Details of the sampling procedures were presented in an earlier report (*5*).

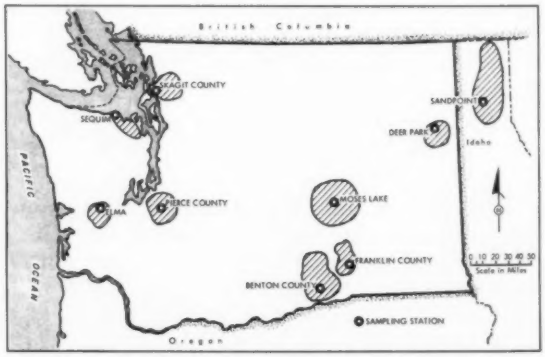

Figure 6. Washington milksheds and sampling locations

Table 3. Radionuclide concentrations in Washington raw milk January–March 1968

Sampling location	Potassium (g/liter)			Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar
Benton County	1.5	NS	1.5	2	NS	1	<15	NS	<15
Deer Park	[a] 1.5	1.5	1.5	5	3	3	[a] <15	<15	<15
Elma	[a] 1.5	1.5	1.6	2	5	3	[a] <15	28	20
Franklin County	NS	1.7	NS	NS	1	NS	NS	<15	NS
Moses Lake	1.3	1.6	1.5	<1	1	3	<15	<15	<15
Pierce County	[a] 1.4	1.6	1.6	1	1	3	[a] <15	<15	<15
Sandpoint, Idaho	[a] 1.4	1.4	1.5	6	3	9	[a] <15	18	23
Sequim	[a] 1.4	NS	NS	1	NS	NS	[a] <15	NS	NS
Skagit County	1.4	1.6	1.4	3	2	3	<15	<15	<15

[a] Two samples represented in average.
NS, no sample.

Selected samples are radiochemically analyzed for strontium–90. Potassium–40, iodine–131, cesium–137, and barium–140 concentrations are determined by gamma-ray scintillation spectrometry. Details of the analytical procedures were presented earlier (*5*).

Table 3 presents monthly radionuclide concentrations in Washington raw milk for January through March 1968. Samples collected during January through March 1968 contained less than 10 pCi/liter of iodine–131. Barium–140 results remained below 15 pCi/liter for all samples collected during this period. Monthly average strontium–90 and cesium–137 concentrations are presented graphically in figure 7 to display general trends.

During this reporting period, three samples were collected (one from Benton County and two from Franklin County) and analyzed for zinc–65. In all three cases, zinc–65 levels were less than 25 pCi/liter. Milk samples produced in areas using Columbia River water for irrigation have periodically been found to contain this radionuclide.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–September 1967	March 1968
October–December 1967	June 1968

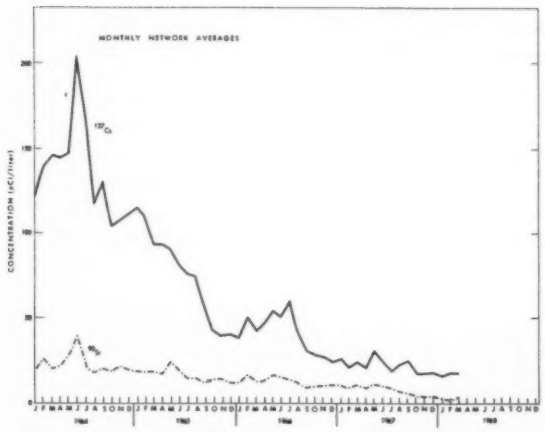
MONTHLY NETWORK AVERAGES
CONCENTRATION (pCi/liter)
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1964
1965
1966
1967
1968

Figure 7. Radionuclide concentrations in Washington milk, 1964–March 1968

REFERENCES

(*1*) HESLEP, J. M. and A. C. CORNISH. California milk network and milkshed comparisons, April–June 1963. Radiol Health Data 4:596–599 (December 1963).

(*2*) STATE OF CALIFORNIA DEPARTMENT OF PUBLIC HEALTH. California milk network, 1960–June 1962. Radiol Health Data 4:90–92 (February 1963).

(*3*) PORTER, C. R., M. W. CARTER, B. KAHN, and E. W. PEPPER. Rapid Field Method for the Collection of Radionuclides from Milk. Proceedings of the First International Congress of the International Radiation Protection Association held in Rome, Italy, September 5–10, 1966 (in press).

(*4*) OREGON STATE BOARD OF HEALTH, DIVISION OF SANITATION AND ENGINEERING. Oregon milk network, April–June 1965. Radiol Health Data 6:683–684 (December 1965).

(*5*) STATE OF WASHINGTON DEPARTMENT OF HEALTH, AIR AND RADIATION CONTROL SECTION. Washington milk network, January–June 1965. Radiol Health Data 6:619–621 (November 1965).

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows.

Program	Period reported	Last presented
California Diet Study	July–October 1967	May 1968
Connecticut Standard Diet	July–December 1967	May 1968
Institutional Total Diet, *PHS*	October–December and annual summary 1967	July 1968
Tri-City Diet, *HASL*	April–December 1967	June 1968

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2-4*), set the limits for approval of a drinking water supply containing radium–226 and strontium–90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium–90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium–90, respectively.

Water sampling program	Period reported	Last presented
California	January–June 1967	June 1968
Colorado River Basin	1965–1966	May 1968
Coast Guard	January–December 1966	November 1967
Minnesota	January–June 1967	January 1968
New York	January–May 1967	January 1968
Radiostrontium in Tap Water, HASL	July–December 1967	June 1968
Florida	1965–1966	July 1968
Washington	July 1966–June 1967	August 1968

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States, March 1968

Division of Pollution Surveillance
Federal Water Pollution Control
Administration
Department of the Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Federal Water Pollution Control Administration's Water Pollution Surveillance System. Table 1 presents the current preliminary results of the alpha and beta radioanalyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium–90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the August 1967 issue of *Radiological Health Data and Reports.*

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1-6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity concentration is 15 pCi/liter or greater or when the beta radioactivity concentration is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data for comment. They reflect no public health

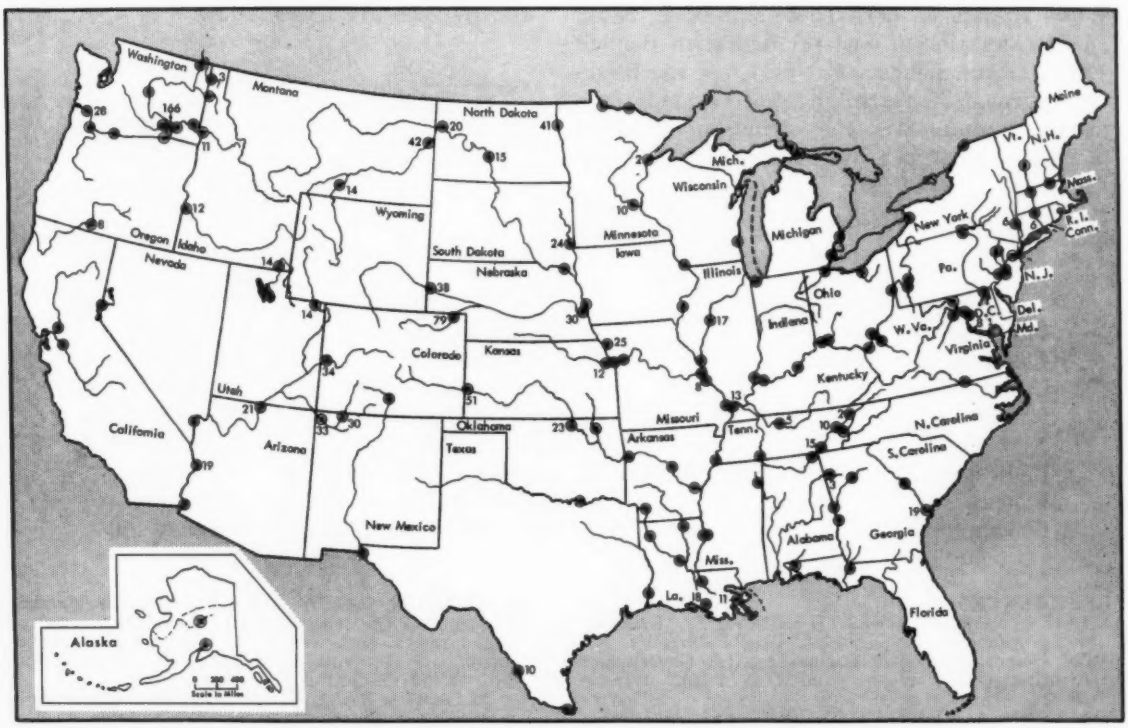

Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, March 1968

Table 1. Radioactivity in raw surface waters, March 1968

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	7	2	9	23	7	30
Arkansas River:						
Coolidge, Kans.	1	37	38	11	40	51
Ponca City, Okla.	0	4	4	3	20	23
Atchafalaya River:						
Morgan City, La.	3	1	4	12	6	18
Bear River:						
Preston, Idaho	0	2	2	0	14	14
Big Horn River:						
Hardin, Mont.	0	5	5	1	13	14
Big Sioux River:						
Sioux Falls, S. Dak.	<1	3	3	4	20	24
Clearwater River:						
Lewiston, Idaho	0	<1	<1	3	8	11
Clinch River:						
Clinton, Tenn.	0	0	0	0	2	2
Kingston, Tenn [a]	0	<1	<1	<1	10	10
Colorado River:						
Loma, Colo.	3	9	12	12	22	34
Page, Ariz.	0	5	5	<1	21	21
Parker Dam, Calif.-Ariz.	0	6	6	1	18	19
Columbia River:						
Pasco, Wash [a]	0	1	1	30	136	166
Clatskanie, Ore.	0	0	0	9	19	28
Connecticut River:						
Enfield Dam, Conn.	0	0	0	2	4	6
Coosa River:						
Rome, Ga.	1	0	1	1	2	3
Cumberland River:						
Cheatham Lock, Tenn.	0	0	0	1	4	5
Great Lakes:						
Duluth, Minn.	0	0	0	0	2	2
Green River:						
Dutch John, Utah	0	2	2	<1	14	14
Hudson River:						
Poughkeepsie, N. Y.	0	0	0	1	5	6
Illinois River:						
Peoria, Ill.	3	1	4	10	7	17
Kansas River:						
DeSoto, Kans.	0	2	2	0	12	12
Klamath River:						
Keno, Ore.	0	<1	<1	1	7	8
Mississippi River:						
St. Paul, Minn.	0	0	0	1	9	10
E. St. Louis, Ill.	0	1	1	1	7	8
New Orleans, La.	1	1	2	3	8	11
Missouri River:						
Williston, N. Dak.	3	1	4	10	10	20
Bismarck, N. Dak.	0	2	2	1	14	15
St. Joseph, Mo.	2	4	6	5	20	25
North Platte River:						
Henry, Nebr.	<1	30	30	3	35	38
Ohio River:						
Cairo, Ill.	3	0	3	8	5	13
Pend Oreille River:						
Albeni Falls Dam, Idaho	0	0	0	<1	3	3
Platte River:						
Plattsmouth, Nebr.	4	5	9	12	18	30
Potomac River:						
Washington, D. C.	1	0	1	5	3	8
Red River, North:						
Grand Forks, N. Dak.	0	<1	<1	2	39	41
Rio Grande:						
Laredo, Tex.	0	2	2	2	8	10
San Juan River:						
Shiprock, N. Mex.	8	3	11	23	10	33
Savannah River:						
Port Wentworth, Ga [a]	<1	0	<1	3	16	19
Snake River:						
Payette, Idaho	0	4	4	1	11	12
South Platte River:						
Julesburg, Colo.	5	35	40	19	60	79
Tennessee River:						
Chattanooga, Tenn.	1	0	1	10	5	15
Yellowstone River:						
Sidney, Mont.	7	3	10	28	14	42
Maximum	8	37	40	30	136	166
Minimum	0	0	0	0	2	2

[a] Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. A discussion of gross radioactivity per gram of solids for all stations of the Water Pollution Surveillance System for 1961 through 1965 has been presented (*7*). Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During February and March the following stations showed values in excess of 15 pCi/liter on alpha radioactivity for dissolved solids:

Arkansas River; Coolidge, Kans.
North Platte River; Henry, Nebr.
South Platte River; Julesburg, Colo.

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(*1*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(*2*) *Ibid.*, 1959 Edition.
(*3*) *Ibid.*, 1960 Edition.
(*4*) *Ibid.*, 1961 Edition.
(*5*) *Ibid.*, 1962 Edition.
(*6*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(*7*) JULIAN, E. C. Gross radioactivity of the solids in selected surface waters of the United States, 1961–1965. Radiol Health Data Rep 9:1–15 (January 1968).

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta-radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*.

Network	Period	Issue
HASL 80th Meridian Network	Calendar year 1965	January 1967

1. Radiation Alert Network May 1968

National Center for Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection when most of the radon daughter products have decayed and at 29 hours after collection when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate National Center for Radiological Health officials by mail or telephone, depending on levels found. Compilation of the daily field estimates is reported elsewhere on a monthly basis (*1*). A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during May 1968. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and deposition, May 1968

Station location		Number of samples		Air surveillance gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Precipitation			
								Total depth (mm)	Field estimation of deposition *		
		Air	Pptn	Maximum	Minimum	Average [a]			Number of samples	Depth (mm)	Total deposition (nCi/m³)
Ala:	Montgomery	22	2	7.31	0.41	2.14	Sept 68	40	2	40	15
Alaska:	Adak	30		1.07	.00	.53	Apr 68	[c]			
	Anchorage	17	6	.48	.00	.07	Dec 67	22	4	18	0
	Attu Island	[b]					May 68	[c]			
	Fairbanks	15	2	1.94	.00	.34	Jan 68	11	2	11	0
	Juneau	21	9	.34	.00	.01	Feb 68	53	9	53	0
	Kodiak	19		1.82	.00	.21	Mar 68	[c]			
	Nome	[b]					July 68	[c]			
	Pt. Barrow	31		1.25	.00	1.14	June 68	[c]			
	St. Paul Island	31		.45	.42	.43	Aug 68	[c]			
Ariz:	Phoenix	21		8.47	1.65	3.67	Feb 68	[c]			
Ark:	Little Rock	9	2	1.49	.33	.85	Dec 67	98	0	0	[c]
Calif:	Berkeley	22	1	.39	.00	.21	Mar 68	4	1	4	0
	Los Angeles	23		1.57	.22	.80	July 68	[c]			
C. Z:	Ancon	17		3.22	1.50	2.45	Mar 68	[c]			
Colo:	Denver	22	2	6.51	.71	2.66	Mar 68	11	[d]	[d]	[d]
Conn:	Hartford	22	8	.57	.24	.28	Jan 68	111	8	111	0
Del:	Dover	22		2.22	.18	.65	Sept 68	[c]			
D. C:	Washington	30	10	1.64	.24	.77	June 68	102	10	102	5
Fla:	Jacksonville	22	6	1.10	.29	.57	Dec 67	132	0	0	[c]
	Miami	21	9	1.65	.16	.41	Jan 68	227	9	227	0
Ga:	Atlanta	22	1	1.27	.41	.99	Aug 68	10	0	0	[c]
Guam:	Agana	6		.67	.00	.23	Sept 68	[c]			
Hawaii:	Honolulu	31		.89	.03	.48	May 68	[c]			
Idaho:	Boise	20	3	5.42	.90	2.11	May 68	9	3	9	0
Ill:	Springfield	17	5	8.25	1.04	2.76	June 68	30	0	0	[c]
Ind:	Indianapolis	20	8	3.52	.64	1.57	Aug 68	157	8	157	312
Iowa:	Iowa City	21	3	5.48	.51	2.34	Mar 68	15	0	0	[c]
Kans:	Topeka	21	7	4.78	.48	1.59	Dec 68	53	7	53	0
Ky:	Frankfort	13	5	.87	.42	.67	June 68	39	5	39	52
La:	New Orleans	22	3	1.02	.24	.56	June 68	47	[d]	[d]	[d]
Maine:	Augusta	20	4	3.01	.09	.59	July 68	63	4	63	0
Md:	Baltimore	19	5	4.07	.34	1.25	Jan 68	22	5	22	7
	Rockville	[b]					May 68	[c]			
Mass:	Lawrence	22	5	1.21	.00	.53	Sept 68	73	1	28	0
	Winchester	21	7	2.58	.00	.46	Apr 68	72	7	72	0
Mich:	Lansing	22	13	3.28	.95	1.95	May 68	105	13	105	664
Minn:	Minneapolis	21	9	.42	.20	.23	Sept 68	108	9	108	94
Miss:	Jackson	18	3	2.16	.30	.86	July 68	126	3	126	124
Mo:	Jefferson City	22	8	4.37	.37	1.27	Aug 68	129	8	129	0
Mont:	Helena	22	5	3.12	.24	1.34	Apr 68	29	5	29	38
Neb:	Lincoln	15	2	4.50	.59	2.53	Aug 68	14	2	14	0
Nev:	Las Vegas	20		2.20	.18	1.16	Jan 68	[c]			
N. H:	Concord	21		2.09	.00	.96	June 68	[c]			
N. J:	Trenton	21	9	1.80	.19	.74	July 68	158	9	158	180
N. Mex:	Sante Fe	19	1	2.36	.22	.77	Apr 68	9	1	9	9
N. Y:	Albany	22	8	2.46	.17	.54	Aug 68	65	8	65	64
	Buffalo	22		1.47	.21	.58	Mar 68	[c]			
	New York City	20		.94	.28	.38	Apr 68	[c]			
N. C:	Gastonia	17	2	10.87	.55	3.75	Mar 68	26	[d]	[d]	[d]
N. Dak:	Bismarck	22	6	4.78	.76	1.79	June 68	68	0	0	[c]
Ohio:	Cincinnati	22		3.89	.51	1.54	Sept 68	[c]			
	Columbus	18	10	1.96	.00	.59	July 68	209	8	189	0
	Painesville	22	12	2.93	.00	.67	Jan 68	86	12	86	67
Okla:	Oklahoma City	15	5	4.54	.21	1.20	May 68	129	5	129	276
	Ponca City	21	7	2.12	.16	.54	Jan 68	106	7	106	0
Ore:	Portland	21	10	1.04	.00	.31	Aug 68	58	10	58	0
Pa:	Harrisburg	17		3.05	.38	1.12	Aug 68	[c]			
P. R:	San Juan	[b]					July 68	[c]			
R. I:	Providence	17		.71	.00	.30	May 68	[c]			
S. C:	Columbia	19	6	.86	.00	.46	Apr 68	36	0	0	[c]
S. Dak:	Pierre	15		7.99	1.02	2.35	Feb 68	[c]			
Tenn:	Nashville	22	8	2.10	.27	.75	May 68	221	8	221	0
Tex:	Austin	20	5	9.48	.34	2.53	Sept 68	90	[d]	[d]	[d]
	El Paso	21		4.48	1.33	2.32	June 68	[c]			
Utah:	Salt Lake City	31	6	1.92	.22	1.01	July 68	21	0	0	[c]
Vt:	Barre	22	7	2.68	.23	1.05	Dec 67	73	7	73	0
Va:	Richmond	15	2	.78	.39	.55	Dec 67	17	0	0	[c]
Wash:	Seattle	25	5	.72	.00	.06	Dec 67	20	[d]	[d]	[d]
	Spokane	22	1	3.46	.74	1.58	Sept 68	1	0	0	[c]
W. Va:	Charleston	21	7	16.91	.25	2.94	Apr 68	78	7	78	52
Wisc:	Madison	22	7	1.26	.20	.69	Dec 67	55	7	55	85
Wyo:	Cheyenne	22	8	6.38	.34	2.32	Jan 68	98	8	98	73
Network summary		1,426	285	16.91	0.00	1.13		71	6	81	60

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] No report received. (Air samples received without field estimate data are not considered by the data program).
[c] No precipitation sample collected.
[d] Indicates that the station is part of the plutonium in precipitation network. No gross beta measurements are done.
[e] Samples were collected but no field estimates were reported.
* The data in these columns apply only to samples for which field estimates were made.

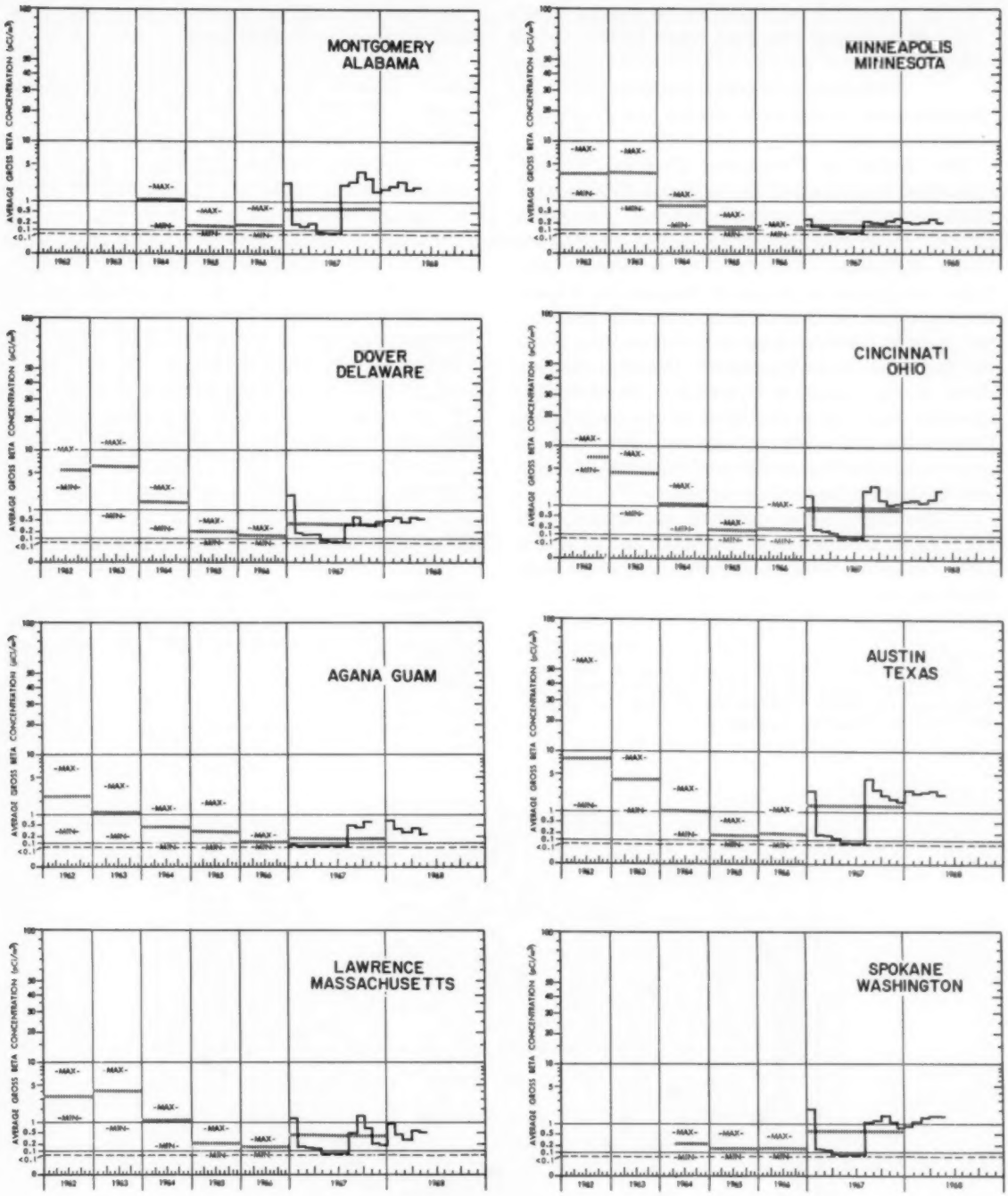

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1962–May 1968

2. Canadian Air and Precipitation Monitoring Program, May 1968 [1]

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*2-6*).

A summary of the sampling procedures and methods of analysis was presented in the April 1968 issue of *Radiological Health Data and Reports.*

[1] Prepared from information and data in the June 1968 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for May 1968 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, May 1968

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition (nCi/m²)
Calgary	31	0.7	0.0	0.3	180	9.3
Coral Harbour	31	.3	.0	.1	195	4.9
Edmonton	31	.5	.0	.2	156	4.6
Ft. Churchill	30	.4	.1	.2	237	2.7
Ft. William	31	.4	.1	.2	117	10.7
Fredericton	31	.3	.0	.2	82	3.5
Goose Bay	31	.3	.0	.1	61	2.8
Halifax	29	.4	.0	.2	74	6.7
Inuvik	31	.3	.0	.1	53	1.1
Montreal	31	.4	.0	.2	97	4.9
Moosonee	31	.5	.0	.2	33	0.6
Ottawa	31	.4	.0	.2	120	5.7
Quebec	31	.3	.0	.1	72	5.2
Regina	31	.5	.0	.2	157	4.7
Resolute	26	.3	.0	.1	52	0.9
St. John's, Nfld.	30	.3	.0	.1	32	4.7
Saskatoon	31	.4	.0	.2	111	6.3
Saulte Ste Marie	27	.6	.0	.2	123	7.6
Toronto	30	.4	.0	.2	111	10.6
Vancouver	31	.5	.0	.2	68	4.3
Whitehorse	31	.3	.0	.1	163	5.2
Windsor	31	.4	.0	.2	75	10.4
Winnipeg	30	.3	.0	.2	83	8.2
Yellowknife	31	.3	.0	.1	177	2.1
Network summary	30	0.4	0.0	0.2	110	5.3

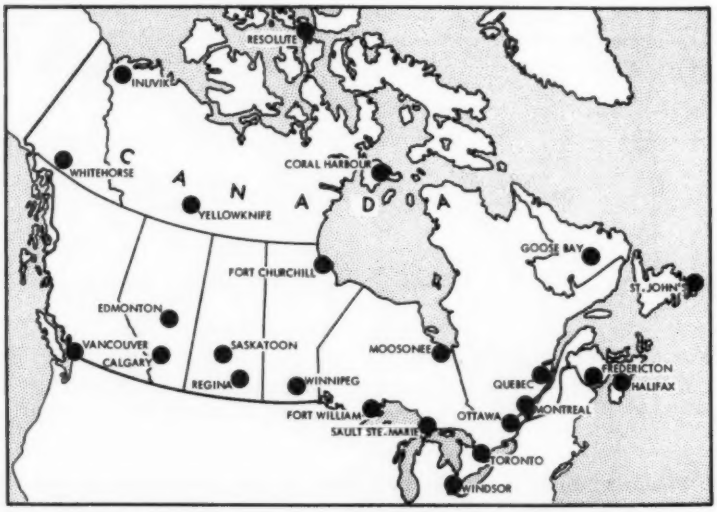

Figure 3. Canadian air and precipitation sampling stations

3. Mexican Air Monitoring Program May 1968

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirrección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Prevision del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high-volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron daughters. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of five samples per month were needed to get a reliable average radioactivity at each station (7).

The maximum, minimum, and average beta radioactivity in surface air during May 1968 are presented in table 3.

Figure 4. Mexican air sampling locations

Table 3. Mexican gross beta radioactivity of airborne particulates, May 1968

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average *
Acapulco	NS	NS	NS	NS
Chihuahua	2	0.4	0.3	—
Ciudad Juarez	5	.5	.2	0.4
Ensenada	NS	NS	NS	NS
Guadalajara	NS	NS	NS	NS
Guaymas	NS	NS	NS	NS
La Paz	15	.5	.1	.4
Matamoros	NS	NS	NS	NS
Masatlán	7	1.2	0.2	.5
Mérida	15	.4	.1	.2
México, D. F.	1	.1	.1	—
Nuevo Laredo	3	.1	.1	.1
San Luis Potosí	NS	NS	NS	NS
Tampico	12	.5	<.1	.1
Terreón	11	.3	.1	.2
Veracruz	2	.1	.1	—

NS, station temporarily shut down, no sample.

4. Pan American Air Sampling Program May 1968

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling locations are shown in figure 5. Analytical techniques were described in the January 1968 *Radiological Health Data and Reports*. The May 1968 air monitoring results from the participating countries are given in table 4.

Table 4. Summary of gross beta radioactivity in Pan American surface air, May 1968

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average *
Argentina: Buenos Aires	22	0.07	0.01	0.02
Bolivia: La Paz	20	.04	.01	.02
Chile: Santiago	29	.06	.01	.03
Colombia: Bogota	21	.03	.00	.01
Ecuador: Guayaquil	20	.07	.02	.03
Jamaica: Kingston	21	.33	.06	.12
Peru: Lima	13	.03	.01	.02
Venezuela: Caracas	17	.22	.03	.16
West Indies: Trinidad	21	.16	.02	.08
Pan American summary	184	0.33	0.00	0.05

* The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

Figure 5. Pan American Air Sampling Program stations

5. Fallout in the United States and Other Areas[2] July–December 1967

Health and Safety Laboratory
Atomic Energy Commission

Monthly fallout deposition rates for strontium–90 are determined by the Health and Safety Laboratory (HASL) for 49 sites in the United States and 107 locations in other countries. HASL data from all of the active United States stations and other selected points in the Western Hemisphere (figure 6) covering the period from July through December 1967, are summarized in tables 5 and 6. All the stations of the 80th Meridian Network are represented.

Methods of collection

Two methods of fallout collection are employed by HASL. In the first, precipitation and dry fallout are collected for a period of 1 month in a stainless steel pot with an exposed area of 0.076 m². At the end of the collection period, the contents are transferred, by careful scrubbing with a rubber spatula, to a polyethylene sample bottle which is then shipped to the laboratory for analysis.

The second method involves the use of a polyethylene funnel, with an exposed area of 0.072 m², attached to an ion exchange column. After a 1-month collection, the inside of the funnel is wiped with a tissue, and the tissue is inserted in the end of the column, which is then sealed and sent to HASL for analysis. It has been shown that at the 95 percent confidence level there was no significant difference in the strontium–90 measurements obtained from samples collected by the two methods (*1*).

Laboratories at Westwood, N. J., New York City, N. Y., and Seattle, Wash., have analyzed monthly precipitation samples for other radionuclides. The amount of precipitation at each station and the monthly deposition rates for

[2] The data in this article were taken from "Fallout Program Quarterly Summary Report," HASL–197:A–4 to A–180; HASL–193:II–9 to II–25 (July 1968; April 1968).

Table 5. Strontium–90 fallout in the United States, HASL, July–December 1967

Sampling location		Type of collection	Deposition (nCi/m²)					
			July	Aug	Sept	Oct	Nov	Dec
Ala:	Birmingham	pot	0.08	0.06	0.03	0.04	0.05	0.04
Alaska:	Anchorage	column	.08	.06	.04	.01	.02	.04
	Barrow	column	.04	.01	T	T	.15	T
	Cold Bay	column	.04	.06	.03	.05	.06	.06
	Fairbanks	column	.08	.08	.01	T	.01	.01
	Juneau	column	.08	.08	.05	T	.04	.03
	Nome	column	.09	.04	.01	.01	T	.02
Calif:	W. Los Angeles	pot	.01	.01	.04	T	.08	T
	San Francisco	column	.01	.01	.01	T	.01	T
Colo:	Denver	column	.08	.04	NS	.05	T	T
Fla:	Coral Gables	pot	.08	.05	.07	NS	NS	NS
	Miami	column	.03	.06	.03	.05	.04	.01
Hawaii:	Hilo	column	.10	.06	.05	.05	.07	.08
	Honolulu	pot	.09	.16	.15	.04	.21	.08
	Lihue	column	.04	.02	.01	.02	NS	.05
	Mauna Loa	column	.03	.01	.01	T	T	T
Ill:	Argonne	pot	.07	.08	.04	.05	.03	.05
La:	New Orleans	column	.05	.04	.02	.01	.01	.02
Minn:	International Falls	column	.18	.07	.03	.02	.01	.03
Mo:	Columbia	column	.03	.03	.03	.05	.01	.04
Mont:	Helena	column	.08	.04	.02	.01	.02	.02
N. J:	Westwood	pot	.10	NS	NS	NS	NS	NS
N. Y:	New York City	pot	.18	.12	.04	.04	.05	.09
N. Dak:	Williston	column	.04	.05	.04	.03	T	.04
Ohio:	Wooster	pot	.07	.07	.06	.03	.02	.04
Okla:	Tulsa	pot	.11	.06	.17	.04	.02	.01
Ore:	Medford	column	.01	.01	.02	.02	.02	.03
S. C:	Columbia	column	.06	.07	.01	T	.03	.02
S. Dak:	Vermillion	pot	.03	.16	.07	.03	T	.01
Tex:	Dallas	column	.06	.02	.05	.03	.02	.01
	El Paso	column	.03	.02	.01	.02	T	.02
	Houston	column	.08	NS	.04	.01	NS	NS
Utah:	Salt Lake City	pot	.06	.02	.04	.02	.03	.10
Va:	Sterling	column	.11	.08	.01	.01	.02	.04
Wash:	Seattle	pot	NS	NS	NS	NS	NS	NS
		pot	.03	T	.03	.08	.06	.06
	Forks	column	.03	.02	.03	T	.08	.01
Wisc:	Green Bay	column	.04	.06	.03	.04	.02	.02

NS, no sample reported.
T, trace or zero.

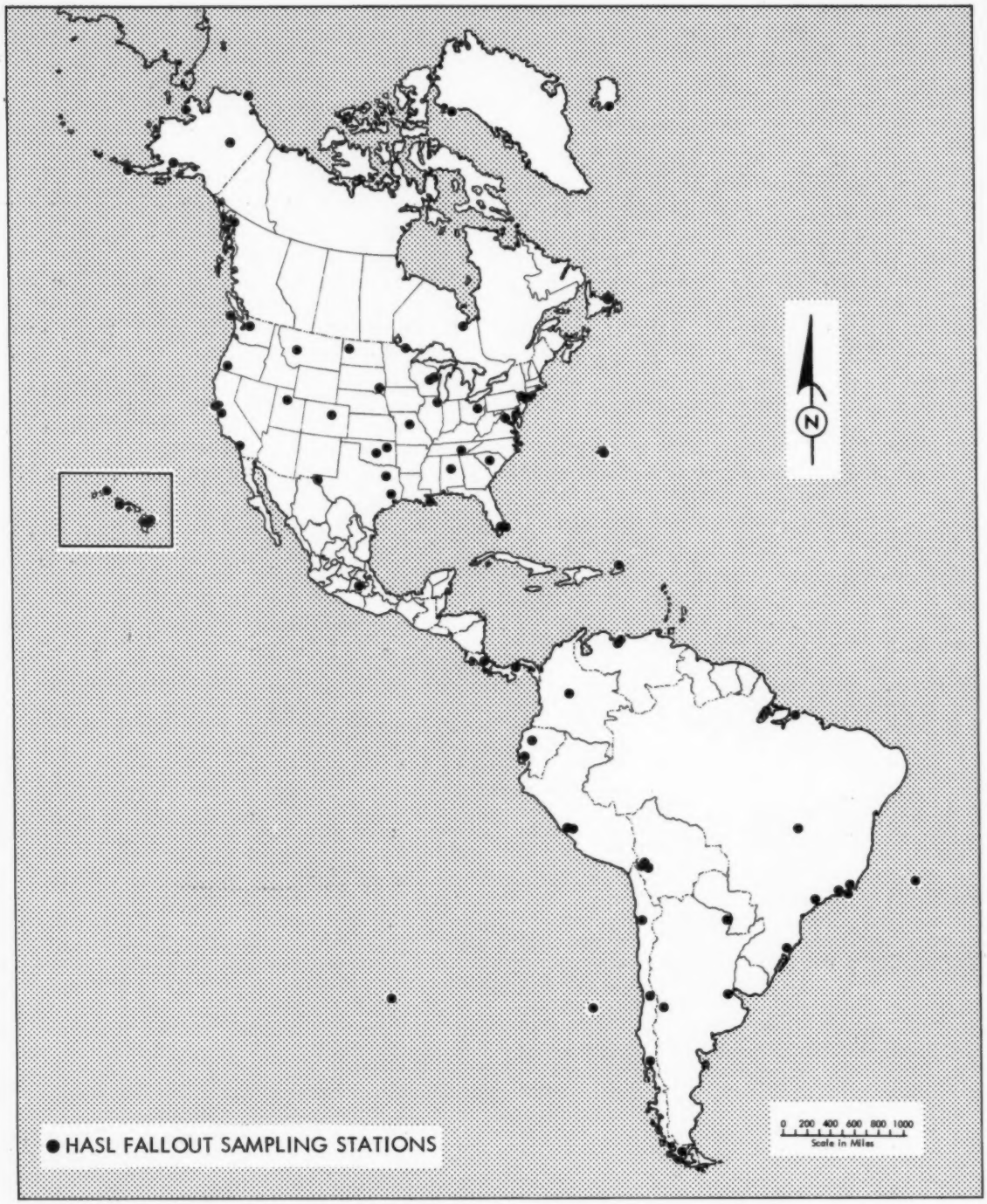

Figure 6. HASL fallout sampling stations in the Western Hemisphere

Table 6. Strontium–90 fallout in North and South America, HASL, July–December 1967

Sampling location		Type of collection	Deposition (nCi/m²)					
			July	Aug	Sept	Oct	Nov	Dec
Argentina:	Buenos Aires	column	0.06	0.08	0.04	0.08	0.06	0.03
	Formosa	column	.01	.02	T	.05	.02	.03
	Malargue	column	.07	T	NS	.02	.02	.02
Bahamas:	Bimini	column	.00	.07	.04	.04	.02	.02
Bermuda:	Kindley AFB	column	.06	.03	.04	.05	.02	.03
Bolivia:	Chacaltaya	column	.01	.01	.03	T	.02	.02
	La Paz (city)	column	.03	.02	.03	.02	.02	.02
	La Paz (Ovejuyo)	column	.04	.02	.03	.02	.02	.02
Brazil:	Belem	column	[b] .03	[b] .03	.01	NS	NS	NS
	Brasilia	pot	NS	NS	NS	NS	NS	NS
	Itaici Sao Paulo	pot	NS	NS	NS	NS	NS	NS
	Nova Friburgo	pot	.02	T	.01	.03	NS	NS
	Rio de Janeiro	column	.01	.05	.08	.03	.04	NS
	San Jose Dos Compos	pot	NS	NS	NS	NS	NS	NS
	San Leopoldo	pot	.02	.04	.08	.10	.03	NS
	Trindade Island	column	NS	NS	.09	NS	NS	NS
Canada:	Moosonee	column	.16	.09	.03	.02	.02	.02
Canal Zone:	Balboa	column	.06	.04	.02	.02	.02	.03
Chile:	Antofagasta	column	NS	NS	NS	NS	NS	NS
	Isla Robinson Crusoe [a]	column	NS	NS	NS	NS	NS	NS
	Easter Island	column	.01	.02	.03	.02	.05	.04
	Puerto Montt	column	.11	.13	.07	.04	T	.05
	Punta Arenas	column	.03	.02	NS	T	.02	.04
	Santiago	pot	.02	.02	.04	.02	T	NS
	Santiago	column	.04	.02	.04	.01	T	.02
Colombia:	Bogota	pot	.01	T	T	T	T	T
Costa Rica:	Turrialba	column	NS	.03	.04	T	.02	T
Equador:	Guayaquil	column	NS	NS	NS	NS	NS	NS
	Quito	column	.02	.01	T	NS	.01	NS
Greenland:	Thule	column	.08	.02	T	T	T	T
Iceland:	Keflavik	column	.01	.05	.06	.02	.02	.06
Mexico:	Mexico City	column	.04	.04	.01	T	T	[b] .01
Peru:	Lima	column	.01	.02	.01	T	T	T
	Lima	column	.01	.01	T	T	T	NS
Puerto Rico:	San Juan	column	.06	.04	.02	.01	.03	.03
Venezuela:	Caracas (site 1)	column	NS	.02	.02	.01	.01	.02
	Caracas (site 2)	column	.02	.01	.02	.01	T	T

[a] I. Alejandro Selkirk
[b] indicates proportioned from originally consolidated data.
NS, no sample reported
T, trace or zero

iron–55, strontium–90, plutonium–238, and plutonium–239–240, at each station are presented in table 7.

Table 7. Radiochemical analyses of precipitation samples at 3 U.S. sites, HASL, July–December 1967

	July	Aug	Sept	Oct	Nov	Dec
Precipitation (cm)						
N. J: Westwood	14.32	NS	NS	NS	NS	NS
N. Y: New York City	17.75	15.09	4.67	8.81	6.58	15.44
Wash: Seattle	0.13	T	3.07	13.77	5.10	13.54
Iron-55 (nCi/m²)						
N. J: Westwood	1.08	NS	NS	NS	NS	NS
Wash: Seattle	2.32	NS	NS	NS	NS	NS
Strontium-90 (nCi/m²)						
N. J: Westwood	0.10	NS	NS	NS	NS	NS
N. Y: New York City	.18	0.12	0.04	0.04	0.05	0.09
Wash: Seattle	NS	NS	NS	NS	NS	NS
Plutonium-238 (nCi/m²)						
N. Y: New York City	.00245	NS	NS	NS	NS	NS
Wash: Seattle	NS	NS	NS	NS	NS	NS
Plutonium-239-240 (nCi/m²)						
N. Y: New York City	.00257	NS	NS	NS	NS	NS
Wash: Seattle	NS	NS	NS	NS	NS	NS

NS, no sample reported.

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

Strontium–90 in Human Bone, April–June 1967[1]

National Center for Radiological Health
Public Health Service

To obtain data on the concentration of strontium–90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. Analyses of selected samples of people in older age groups have shown their bone strontium–90 content to be low and age-independent (*1*). Consequently, the target population includes children and young adults up to 25 years of age.

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available from older children, but it presents some difficulties from the standpoint of infants and children under 5 years of age.

[1] Period during which death or surgical procedure occurred.

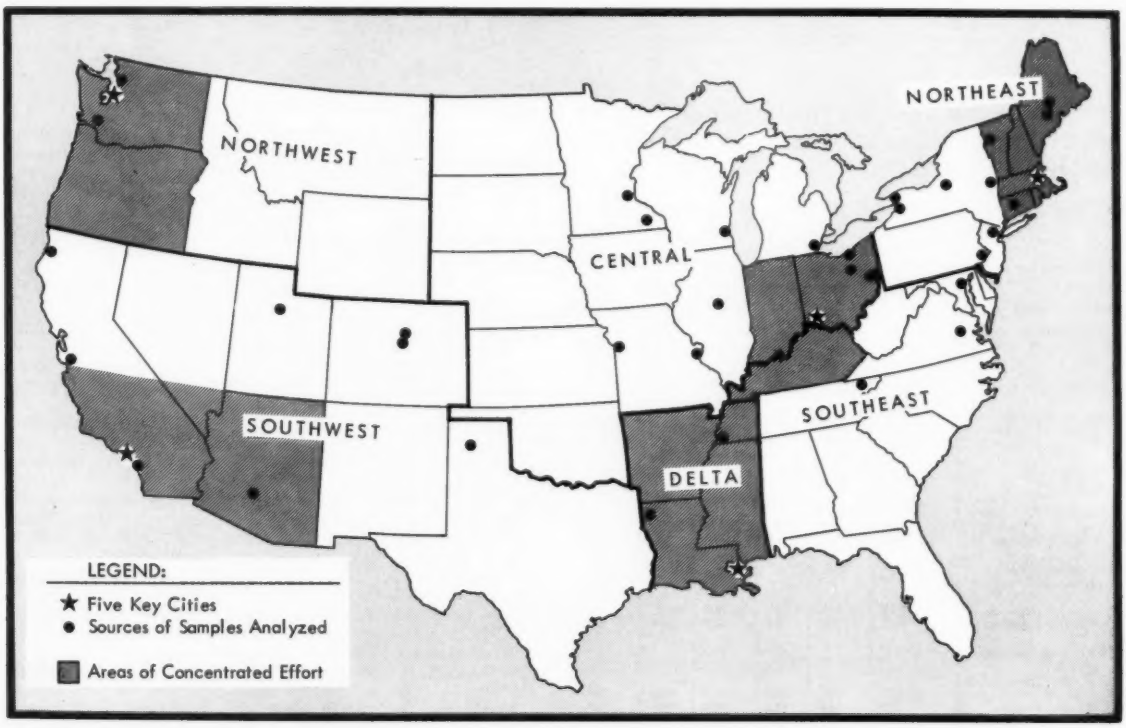

Figure 1. Geographical regions for human bone sampling

Table 1. Strontium-90 in human bone, April–June 1968

Bone region and State of residence	Bone type [a]	Age [b] (years)	Sex	Strontium-90 concentration (pCi/kg bone)	Calcium concentration (g/kg bone)	$^{90}Sr/Ca$ (pCi/g)
Northeast:						
Pennsylvania	V	01	M	112.0 ± 02.0 [c]	25.0	4.48
New York	V	02	M	119.0 ± 13.0	22.8	5.21
Vermont	V	03	F	152.0 ± 9.2	32.5	4.67
New York	V	05	M	88.1 ± 11.0	31.8	2.77
Massachusetts	V	06	F	137.0 ± 11.0	30.9	4.43
New York	V	06	F	86.1 ± 8.3	27.2	3.16
New York	V	06	M	88.1 ± 7.9	37.1	2.37
Vermont	V	07	F	208.0 ± 13.0	45.9	4.53
New York	V	07	F	69.3 ± 8.7	24.7	2.80
Pennsylvania	V	08	M	226.0 ± 23.0	147.0	1.53
Connecticut	V	08	M	78.5 ± 12.0	29.8	2.63
Pennsylvania	V	08	F	62.3 ± 6.6	29.2	2.13
Maine	V	09	M	127.0 ± 8.3	37.3	3.40
Massachusetts	V	10	F	373.0 ± 15.0	43.1	8.65
Massachusetts	V	11	F	120.0 ± 10.0	40.4	2.97
New York	V	12	F	108.0 ± 18.0	42.4	2.54
New York	V	13	F	167.0 ± 11.0	58.2	2.86
Massachusetts	V	14	M	144.0 ± 14.0	37.4	3.85
Connecticut	V	14	M	139.0 ± 8.9	33.6	4.13
Connecticut	V, R	14	F	83.1 ± 8.8	38.2	2.17
Massachusetts	V	15	F	200.0 ± 9.6	44.3	4.51
Massachusetts	V	15	F	120.0 ± 9.7	42.3	2.83
Vermont	V	16	M	66.0 ± 8.7	46.4	1.43
Connecticut	V, R	16	M	148.0 ± 10.0	45.1	3.28
New York	V	17	M	171.0 ± 12.0	82.2	2.08
Connecticut	V, R	17	M	286.0 ± 21.0	64.5	4.43
New York	V	18	M	136.0 ± 11.0	47.7	2.85
Massachusetts	V	19	F	114.0 ± 11.0	41.6	2.74
Massachusetts	V	19	M	115.0 ± 12.0	50.6	3.06
New York	V	19	M	130.0 ± 16.0	56.3	2.30
Connecticut	V, R	20	M	115.0 ± 12.0	43.9	2.61
Connecticut	V, R	20	F	63.7 ± 8.3	45.1	1.41
New York	V	20	M	106.0 ± 9.5	46.8	2.26
New York	V	20	M	80.6 ± 9.3	32.7	2.46
Connecticut	V	20	M	106.0 ± 12.0	61.0	1.72
Massachusetts	V	23	M	82.5 ± 8.4 [c]	40.6	2.03
Connecticut	V	23	M	63.9 ± 6.9	42.6	1.50
New York	V	23	M	121.0 ± 21.0	50.8	2.38
Massachusetts	V	25	M	71.2 ± 10.0	40.3	1.76
New York	V	25	M	94.9 ± 8.9	42.9	2.21
Southeast:						
North Carolina	V	01	M	150.0 ± 20.0	25.2	5.95
South Carolina	V	01	M	137.0 ± 24.0	32.4	4.22
North Carolina	V	01	M	143.0 ± 18.0	30.6	5.03
Maryland	V	02	M	147.0 ± 26.0	36.4	4.03
Maryland	V	02	M	147.0 ± 23.0	29.3	5.01
North Carolina	V	02	F	177.0 ± 26.0	20.0	8.85
North Carolina	V	03	F	197.0 ± 31.0	23.0	8.56
South Carolina	V	04	F	143.0 ± 21.0	29.1	4.91
Maryland	V	05	F	177.0 ± 25.0	37.0	4.78
Maryland	V	06	F	03.5 ± 19.0	30.5	3.06
Maryland	V	06	M	78.4 ± 12.0	34.3	2.28
Maryland	V	07	M	122.0 ± 14.0	37.5	3.25
South Carolina	V	07	M	107.0 ± 12.0	37.6	2.84
Maryland	V	08	M	63.6 ± 10.0	38.1	1.66
Maryland	V	08	F	75.7 ± 16.0	39.4	1.92
Georgia	V	08	F	60.8 ± 14.0	26.3	2.31
South Carolina	V	09	F	245.0 ± 39.0	36.2	6.76
Maryland	V	11	F	104.0 ± 8.5	40.3	2.58
South Carolina	V, S	11	F	215.0 ± 16.0	46.7	4.60
North Carolina	V	14	M	94.3 ± 9.0	42.8	2.22
Georgia	V	14	M	88.5 ± 11.0	37.4	2.36
North Carolina	V	15	F	198.0 ± 18.0	49.3	4.01
South Carolina	V	15	F	85.8 ± 15.0	55.0	1.56
Maryland	V	16	M	127.0 ± 12.0	46.9	2.70
Maryland	V	16	M	115.0 ± 12.0	64.4	1.78
Maryland	V	16	M	177.0 ± 17.0	55.3	3.20
Maryland	V	16	M	253.0 ± 25.0	55.9	4.52
North Carolina	V	16	M	160.0 ± 14.0	46.2	3.46
Maryland	V	17	M	157.0 ± 16.0	57.5	2.73
Georgia	V	17	M	146.0 ± 21.0	51.6	2.82
Kentucky	V	17	F	98.9 ± 13.0 [c]	67.6	1.46
Maryland	V	18	M	216.0 ± 21.0	50.7	4.26
Maryland	V	18	M	138.0 ± 12.0	54.7	2.52
North Carolina	V	19	M	192.0 ± 22.0	48.9	3.92
Georgia	V	19	F	172.0 ± 13.0	50.2	3.42
Maryland	V	20	M	114.0 ± 15.0	66.7	1.70
Maryland	V	20	M	93.9 ± 10.0	47.2	1.98
Maryland	V	20	F	122.0 ± 13.0	53.6	2.27
Virginia	V	20	M	154.0 ± 22.0	67.8	2.27

See footnotes at end of table.

Table 1. Strontium-90 in human bone, April–June 1968—Continued

Bone region and State of residence	Bone type [a]	Age [b] (years)	Sex	Strontium-90 concentration (pCi/kg bone)	Calcium concentration (g/kg bone)	$^{90}Sr/Ca$ (pCi/g)
Southeast: (Continued)						
Maryland	V	21	M	136.0 ± 25.0	53.0	2.56
Maryland	V	21	M	139.0 ± 16.0	53.3	2.60
North Carolina	V	21	M	147.0 ± 37.0	55.2	2.66
North Carolina	V	21	M	134.0 ± 18.0	50.0	2.68
Maryland	V	22	M	101.0 ± 13.0	54.3	1.86
Maryland	V	22	M	149.0 ± 21.0	53.3	2.79
Georgia	V	22	M	123.0 ± 19.0	51.8	2.37
Maryland	V	23	M	178.0 ± 20.0	62.0	2.87
Maryland	V	24	M	187.0 ± 16.0	58.8	3.18
Maryland	V	24	M	64.2 ± 13.0	52.3	1.22
Maryland	V	24	M	92.5 ± 18.0	65.1	1.42
Maryland	V	25	M	67.9 ± 14.0	60.0	1.13
Maryland	V	25	M	120.0 ± 16.0	53.2	2.25
Maryland	V	25	F	187.0 ± 22.0	62.0	3.01
North Carolina	V	25	F	52.8 ± 33.0	40.4	1.30
South Carolina	V	25	M	66.2 ± 8.9	49.5	1.33
South Carolina	V	25	F	90.3 ± 13.0	36.0	2.50
Central:						
Wisconsin	V	00	M	84.4 ± 20.0	34.4	2.45
Ohio	V	00	M	103.0 ± 16.0	26.6	3.87
Wisconsin	V	01	M	181.0 ± 24.0	40.8	4.43
Wisconsin	V	01	F	120.0 ± 17.0	32.6	3.68
Wisconsin	V	01	M	65.0 ± 12.0	27.1	2.39
Wisconsin	V	01	M	103.0 ± 17.0	28.7	3.58
Wisconsin	V	01	M	91.6 ± 14.0	31.5	2.90
Wisconsin	V	01	F	93.1 ± 18.0	22.3	4.17
Indiana	V	02	M	159.0 ± 25.0	31.3	5.07
Ohio	V	02	M	149.0 ± 25.0 [c]	40.8	3.65
Wisconsin	V	04	M	82.2 ± 22.0	37.0	2.22
Michigan	V	04	M	184.0 ± 16.0	36.6	5.02
Ohio	V	04	M	105.0 ± 19.0	34.0	3.08
Iowa	V	04	F	42.9 ± 18.0	29.0	1.47
Illinois	V	05	M	91.1 ± 14.0	32.1	2.83
Wisconsin	V	06	M	147.0 ± 16.0	35.4	4.15
Wisconsin	V	06	F	74.2 ± 10.0	40.1	1.85
Wisconsin	V	06	F	65.2 ± 10.0	28.0	2.32
Ohio	V	06	M	133.0 ± 11.0	31.7	4.19
Ohio	V	08	M	132.0 ± 11.0	30.9	4.27
Ohio	V	09	F	77.5 ± 10.0	31.4	2.46
Wisconsin	V	10	F	113.0 ± 12.0	38.0	2.97
Ohio	V	10	M	143.0 ± 24.0	58.5	2.44
Wisconsin	V	11	M	58.6 ± 8.8	35.5	1.65
Michigan	V	15	F	111.0 ± 13.0	41.4	2.68
Ohio	V	16	M	175.0 ± 18.0	71.6	2.44
Ohio	V	17	M	237.0 ± 21.0	65.2	3.63
Ohio	V	17	M	125.0 ± 19.0	45.5	2.74
Wisconsin	V	17	M	92.1 ± 14.0	56.9	1.61
Ohio	V	19	F	96.2 ± 16.0	68.0	1.41
Wisconsin	V	19	M	66.1 ± 13.0	42.0	1.57
Ohio	V	20	M	136.0 ± 26.0	62.3	2.18
Ohio	V	21	M	164.0 ± 11.0	61.1	2.68
Minnesota	V	21	F	70.1 ± 11.0	53.1	1.32
Ohio	V	24	F	92.4 ± 26.0	74.7	1.23
Ohio	V	25	M	150.0 ± 22.0	75.5	1.98
Ohio	V	26	F	75.3 ± 32.0	68.9	1.09
Delta:						
Louisiana	V, R	03	M	227.0 ± 20.0	39.2	5.79
Louisiana	V	04	M	78.4 ± 14.0	20.3	3.86
Louisiana	V	04	M	54.9 ± 14.0	20.3	2.70
Louisiana	V	06	F	97.3 ± 18.0	25.9	3.75
Louisiana	V, R	10	M	62.6 ± 13.0	33.2	1.88
Louisiana	V	12	F	125.0 ± 23.0	46.3	2.69
Louisiana	V, R	18	M	138.0 ± 19.0	60.0	2.30
Louisiana	V	02	M	157.0 ± 24.0 [c]	47.4	3.31
Northwest:						
Oregon	V	01	M	85.5 ± 13.0	29.1	2.93
Oregon	V	02	M	122.0 ± 11.0	34.3	3.55
Oregon	V	04	M	126.0 ± 9.9	29.2	4.31
Washington	V	08	F	157.0 ± 14.0	32.6	4.81
Oregon	V	18	M	200.0 ± 12.0	78.9	2.53
Ohio	V	20	M	214.0 ± 22.0	85.1	2.51
Oregon	V	21	M	131.0 ± 9.6	55.9	2.34
Oregon	SK	24	M	174.0 ± 18.0	05.0	0.84
Oregon	V	24	M	51.2 ± 9.1	52.7	0.97
Washington	V	24	M	43.1 ± 7.2	48.8	0.88
Southwest:						
Texas	V	03	F	62.3 ± 17.0	27.9	2.23
Texas	V	04	M	81.1 ± 15.0	26.8	3.02
Colorado	V	08	M	70.1 ± 14.0	27.0	2.59
Colorado	V	11	F	115.0 ± 11.0	42.2	2.72
Colorado	V	16	M	77.7 ± 7.4	47.8	1.62
California	V	19	M	61.7 ± 9.0	59.6	1.03
Texas	V	20	F	60.2 ± 12.0	43.7	1.37

[a] Type of bone: V, vertebrae; R, rib; S, sternum; SK, skull
[b] Age given as of last birthday prior to death.
[c] Two-sigma counting error

Most specimens received to date have been vertebrae and ribs.

Laboratory procedures

The bones are analyzed at the Northeastern Radiological Health Laboratory of the National Center for Radiological Health, at Winchester, Mass. Sample collection and preparation are explained elsewhere (*2*). Strontium–90 is measured by tributyl phosphate extraction of its yttrium daughter, which is precipitated as an oxalate. The strontium–90 content is then calculated (*3*) from the yttrium–90 activity. For the purpose of maintaining analytical reproducibility, "blind" duplicate analyses are performed on 10 to 20 percent of the samples. To further check and maintain analytical accuracy, synthetic "bone ash" samples (calcium phosphate spiked with strontium–90) are analyzed periodically and crosscheck analyses are carried out quarterly with the Health and Safety Laboratory of the AEC, which performs similar analyses.

The analytical results for strontium–90 in individual bones from persons dying during the second quarter (April–June) of 1967 are presented in table 1 in order of increasing age within each geographical region. These regions are indicated in figure 1. Reported values are given in picocuries of strontium–90 per kilogram of bone (as a rough indication of dose) and per gram of calcium (for comparison with other data and for purposes of model development). Two-sigma counting errors are reported for the bone concentration.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (*2-5*).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
October–December 1966	September 1967
January–March 1967	June 1968

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(*1*) RIVERA, J. Strontium–90 in human vertebrae, 1962–1963. Radiol Health Data 5:511–513 (October 1964).

(*2*) WEISS, E. S., W. H. LAND, K. H. FALTER, and R. M. HALLISEY. Strontium–90 content of human bones, 1961–1963. Radiol Health Data 5:231–239 (May 1964).

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(*4*) GAFFNEY, G. W., R. M. HALLISEY, M. S. MILLER, and A. S. GOLDIN. Strontium–90 in human bone, 1962–1963. Radiol Health Data 5:620–628 (December 1964).

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Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the AEC Manual.[1]

Summaries of data from the environmental radioactivity monitoring reports follow for the Lawrence Radiation Laboratory and Mound Laboratory.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Lawrence Radiation Laboratory July–December 1967 [2]

University of California
Berkeley, California

Berkeley Site

The Berkeley site of the Lawrence Radiation Laboratory (LRL) is situated on the western slope of the range of hills running along the eastern side of San Francisco Bay. The laboratory is largely separate from the main campus of the University, although there is some overlap (figure 1).

To the north and south of the laboratory area are residential areas of the cities of Berkeley and Oakland. The Berkeley campus of the University of California is on the west; to the east, are the Lawrence Hall of Science and the Space Sciences Laboratory, beyond them lies uninhabited watershed land and the Tilden Regional Park.

The most prevalent wind direction is westerly. During the summer months the afternoon sea breeze establishes a very pronounced prevailing westerly wind direction. At other times, the direction is less predictable. Annual rainfall is 23 inches, almost all of which falls between November 1 and May 1. The prevailing wind direction during precipitation is southerly.

The laboratory carries on a wide ranging program of general research in the fields of both physical and biological sciences. Facilities include a number of large accelerators, and various physics, chemistry, biology and medical research laboratories.

The basic policy at LRL has long been to prevent, as far as possible, any release of radioactive material to the environment, no matter how small. No deliberate releases are sanctioned, except where no practical method for containment has yet been developed and quantities are small compared with standards established by the ICRP and AEC.

The most sensitive measurements of releases are those taken closest to the source itself, before dilution makes detection of small quantities more difficult. The stack sampling program, therefore, provides the most useful information for controlling releases to the atmosphere. Over 100 separate exhausts from hoods and glove box manifolds are sampled. The total quantities released from these stacks during the 6 months were 0.1 microcuries of alpha-particle emitters and 400 microcuries of beta-particle emitters. The average concentrations in the total exhaust, before any dilution by the atmosphere, was 7 percent of the maximum permissible concentration for offsite breathing zone air, as given by the ICRP.

In addition to the careful sampling of stacks, an environmental air sampling program is also carried on to make sure no undetected releases occur. These samples provide a direct measurement of possible exposure to the nearby population. The sampling stations designated "local area" are scattered around the site and provide samples of the atmosphere on the site itself. The "perimeter" samples are taken at the boundary line of University property, in the direction of populated areas. From the results of these samples, it is apparent that there has been no significant exposure from radioactive materials released by LRL. The levels of radioactivity observed in each type of sample are presented in table 1.

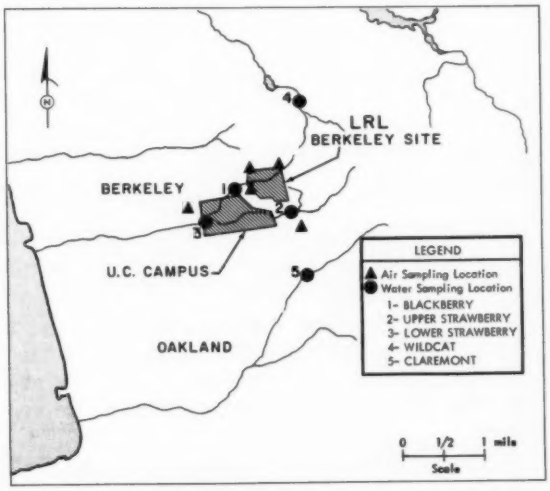

Figure 1. Environmental sampling locations at the Berkeley site

[2] Summarized from "Results of Environmental Radioactivity Sampling Program July–December 1967," Lawrence Radiation Laboratory, Livermore and Berkeley, Calif.

Table 1. Atmospheric monitoring, LRL Berkeley site July-December 1967

Sampling locations (number of locations)	Number of samples	Concentration (pCi/m³)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum	Average	Maximum
Local area (10)	258	0.000	0.006	0.02	0.29
Perimeter (4)	101	.001	<.005	.04	.24

At each of these environmental stations rain or dry "fallout" is also collected. Open 15-inch diameter polyethylene bags form the collecting vessel. If no rain has fallen, the bags are rinsed out with dilute nitric acid. Results from these collections show a lot of variation, without any consistent pattern. Since on the average, the more remote perimeter stations show about the same radioactivity as the nearer ones, it must be assumed that the radioactivity does not result from laboratory operations. The radioactivity levels in samples collected at each location are summarized in table 2.

Table 2. Total deposition, LRL Berkeley site July-December 1967

Sampling locations (number of locations)	Number of samples	Deposition (nCi/m²)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum[a]	Average	Maximum[a]
Local area (9)	47	0.10	0.29	1.27	1.85
Perimeter (4)	21	.11	.15	1.24	1.89

[a] Maximum deposition at a single location for the 6-month period.

All liquid waste known to be radioactive is collected, solidified, and shipped away. Other liquid wastes are discharged directly to the municipal sewer system. Occasionally, small quantities of radioisotopes are accidentally released to the sewer system. There are two outfalls, each of which is monitored by a continuous proportional sampling system to insure that no significant quantities have been discharged. The total concentration (alpha plus beta radioactivity) in sewage is only 25 percent of the standard for drinking water and therefore does not constitute a serious exposure threat. A sizeable fraction of the measured beta concentration is the naturally occurring isotope potassium–40 from human wastes and chemicals.

The storm drainage from the laboratory flows into the surface stream system. These surface streams are exposed as they run through the University property and are sampled at three places. Results are listed as "onsite streams" in the table. Two nearby offsite streams are also sampled to provide a comparison. No alarming concentrations have been observed. All are safely below the standard for drinking water. The results from the water sampling program are presented in table 3.

Table 3. Water monitoring, LRL Berkeley site July–December 1967

Type and source of sample	Number of samples	Concentration (pCi/liter)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum	Average	Maximum
Sewage:					
Hearst sewer	26	0.8	5.6	25.7	47.0
Strawberry sewer	26	.3	2.7	10.7	47.0
Tap water	24	.01	.44	2.00	3.5
Surface water:					
Onsite streams	78	.5	4.8	8.4	47.8
Offsite streams	52	.9	5.8	2.4	6.4

Neutron and gamma-ray fields are measured at each of the four perimeter stations as well as at several locations within the site. Background measurements are obtained from a leased building used as a low level counting room in downtown Berkeley. This building is remote from the main LRL site and measurements are not influenced by accelerator operations.

Levels were somewhat higher than they were during the first 6 months of the year due to the resumption of Bevatron operations. However, the radiation levels were well below the standards set for the general public by the ICRP and NCRP.

Livermore site

The Livermore site of LRL (figure 2) is located in the Livermore Valley midway be-

tween the Pacific coast and the San Joaquin Valley in northern California—approximately 50 miles southeast of San Francisco. Shielded from the ocean by the western hills, the Livermore Valley has a warm, dry climate. Annual rainfall is about 14 inches and the relative humidity is about 30 percent during the summer months and about 40-50 percent the remainder of the year. Prevailing winds are from the west, but inversions are frequent during the night. Technical facilities include a small cyclotron, a 2-megawatt swimming pool reactor, and physics and chemistry programs associated with a weapons development program.

Agriculture is the principal activity in the Livermore Valley. Roses, grain, hay, and grapes are the major products. Several cattle and sheep ranches surround the Livermore site.

The Livermore site comprises an area of 1-square mile, approximately 3 miles east of the city of Livermore. Livermore and Pleasanton, with a combined population of 45,000, are populated areas of primary interest to the Livermore site.

An environmental sampling program is maintained to provide information regarding the effectiveness of control measures and to determine whether any radiological changes in the environment are the result of laboratory operations. The sampling program includes air particulates, soil, domestic water, sewer effluent, sewage plant products, milk, and vegetation. The milk samples are obtained from two dairies in the Livermore Valley and one in another valley about 25 miles away, which is used as a check. The water samples are collected to monitor radioactivity in an underground water supply which provides most of the domestic water for the cities of Livermore and Pleasanton, and is the sole supply for ranches in the Livermore and Amador Valleys.

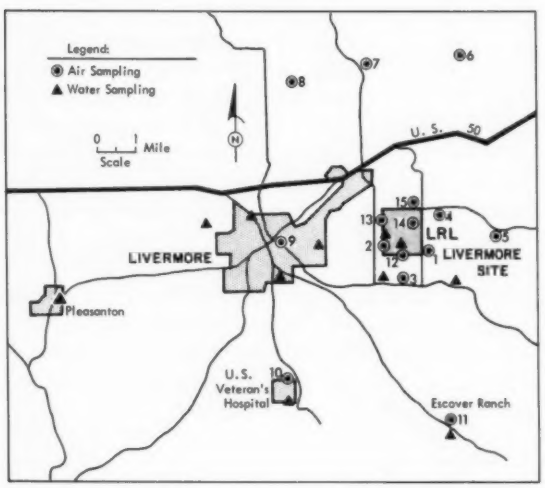

Figure 2. Environmental sampling locations at the Livermore site

Air samples are collected continuously at 15 sites within 5 miles of the laboratory. Samples are collected at a rate of 4 cfm on 100-square centimeter HV–70 filter papers, which are changed after every 7 days of operation. A minimum decay period of 96 hours is observed before the samples are counted to eliminate the effect of natural radon and thoron daughters. All environmental air samples are counted in an automated system which utilizes gas flow proportional detectors for both alpha and beta radioactivity measurements. Alpha radioactivity in 450 air samples collected from 16 sampling locations averaged less than 0.001 pCi/m^3. The average beta radioactivity was lower than the average for last year—0.02 pCi/m^3 (1967), versus 0.05 pCi/m^3 (1966). The applicable AEC radiation protection standards are 0.040 pCi/m^3 for alpha-particle emitters and 1 pCi/m^3 for beta-particle emitters.

The measurement of low level "background" radiation during this period was accomplished with thermoluminescent dosimeters located at nine points on the site perimeter and at two nearby ranches. The limit of detection for these dosimeters is 20 mR. One dosimeter at a point opposite cobalt–60 irradiation facility recorded 150 mR for the 6-month period. One dosimeter opposite an experimental physics facility recorded 20 mR. All others were below the limit of sensitivity or less than 0.005 mR/hr.

Domestic water samples were collected monthly from nine nearby sources. No sample showed an alpha specific radioactivity above the limit of sensitivity (5.0 pCi/liter). The beta radioactivity fluctuated from the limit of sensitivity (1.8 pCi/liter) to 14 pCi/liter. The average beta radioactivity concentration was 3.3 pCi/liter. The average alpha and beta radioactivity concentrations were below the re-

spective standards of comparison of 10 and 100 pCi/liter stated in AEC standards.

The average tritium content was at or below the limit of sensitivity (5,000 pCi/liter), which is well below the standard of comparison of 3×10^6 pCi/liter.

Samples were collected daily at the laboratory sewer discharge. The average concentration of radionuclides in the sewer effluent was 30 ± 3 pCi/liter of alpha radioactivity and 81 ± 8 pCi/liter of beta radioactivity. The standard of comparison is 300 pCi/liter for both alpha and beta radioactivity. The tritium content of the effluent was 3.9×10^4 pCi/liter.

Samples of top layer soil are collected quarterly at the 19 sampling stations surrounding the Livermore site. The alpha radioactivity fluctuated from the limit of sensitivity (1.5 pCi/g) to 11 pCi/g. The beta radioactivity fluctuated from the limit of sensitivity (3.5 pCi/g) to a single sample high of 13 pCi/g. The average alpha radioactivity was 2.0 pCi/g and the average beta radioactivity was 7.0 pCi/g. The concentrations detected are within the normal range for soil in the Livermore Valley.

Average radioactivity levels in monthly milk samples amounted to 4 pCi/liter of cesium–137 and 10 pCi/liter of cerium–141–144, for the two Livermore dairies. The average tritium concentration in milk was at or below the limit of sensitivity (5,000 pCi/liter).

Site 300

The high explosive test area at Site 300 (figure 3) covers 10 square miles in the hills in a very sparsely populated ranching area about 15 miles southeast of Livermore and 8 miles southwest of Tracy. The chief area of concern for Site 300 is Tracy. The population there is about 15,000. Air and water samples are taken to determine whether operations at Site 300 are changing the normal radioactivity levels in the vicinity. The eight air samplers at Site 300 are operated at about 50 cfm on a continuous basis with the filter papers being changed on regular schedule. Most of these air samplers are located within the boundaries of the test site due to unavailability of power

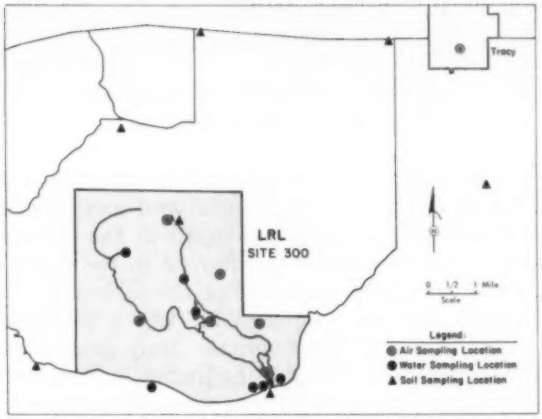

Figure 3. Sampling locations at Site 300, LRL

facilities offsite. Water samples are taken from six onsite wells because they are the only readily accessible sources of underground water. Two samples showed an alpha radionuclide concentration above the limit of sensitivity (5.0 pCi/liter) one at 90 pCi/liter and one at 61 pCi/liter. Resampling showed these locations to be below the limit of sensitivity and contamination of the original samples during processing is suspected. All others were below the limit of sensitivity. The beta concentrations ranged from the limit of sensitivity (1.8 pCi/liter) to 33 pCi/liter, averaging 5.5 pCi/liter. Samples are collected from streams only during the winter months when water flow exists. Soil samples are collected quarterly at nine offsite locations. Only top layer soil is collected to determine fallout concentrations. All air, water, and soil samples are processed at the laboratory in Livermore. The average radioactivity levels in samples collected are summarized in table 4.

Table 4. Environmental sampling, Site 300 July-December 1967

Type of sample (concentration units)	Average alpha radioactivity	Average beta radioactivity
Air (pCi/m³)	0.0004	0.024
Water (pCi/liter)	<5.0	5.5
Soil (pCi/g)	6	6

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1966	November 1967
January–June 1967	April 1968

2. Mound Laboratory July–December 1967 [3]

Monsanto Research Corporation
Miamisburg, Ohio

The environmental monitoring program for Mound Laboratory is planned and coordinated with all the projects conducted at the laboratory. Air and water monitoring in the uncontrolled environs surrounding the laboratory is specific for the radionuclides which could be released to the environment. Only polonium–210, plutonium–238, and hydrogen–3 (tritium) are potential environmental contaminants.

Air monitoring

Mobile air monitoring equipment, mounted on a 1-ton panel truck, for measurement of tritium and collection of particulate alpha-particle emitters was used in the routine monitoring of environmental air in a network of 111 locations within a radius of 20 miles from the laboratory during the collection period. The choice of sites on a given day was dependent upon the wind direction at the time of collection.

Airborne polonium and plutonium particulates are collected with a high volume air sampler. The filter papers are then processed such that counting results are specific for polonium and plutonium. One fourth of each filer paper is processed by spontaneous deposition to isolate polonium. Plutonium is isolated by processing the remaining three fourths of each filter paper through a resin column.

Prior to August 22, 1967, airborne tritium was monitored by drawing air through a calcium chloride drying tube and then analyzing the collected moisture for tritium. Beginning August 22, 1967, the procedure was changed to bubbling an air sample through a liquid scintillation counting solution with p-dioxane as the organic solvent. The counting solution is then counted directly in a liquid spectrometer.

Beginning January 1, 1967, all particulate air samples collected in the same zone, in the same range, and on the same day are combined before processing and are considered as one sample. This is done to improve the lower detectable limit for plutonium.

The results of the airborne monitoring program are presented in tables 5, 6 and 7. The average concentrations of plutonium, polonium, and tritium in the environment are below the AEC radiation protection standards.

Table 5. Atmospheric monitoring of polonium–210, Mound Laboratory environs, July–December 1967

Range (miles)	Number of samples	Concentration [a] (pCi/m³)		Average as percent of AEC standards [b]
		Maximum	Average	
0–3 (upwind)	21	0.6690	0.0159	0.26
0–3 (downwind)	21	.0320	.0173	.09
3–5 (downwind)	21	.6892	.0561	.28
5–10 (downwind)	21	.0991	.0315	.16
10–15 (downwind)	21	.0800	.0259	.13
15–20 (downwind)	21	.0366	.0179	.09

[a] Lowest detectable level (LDL) for polonium-210 in air is 0.0080 pCi/m³ for samples collected 0–3 miles upwind, 3–5 miles downwind, 5–10 miles downwind, and 10–15 miles downwind. The LDL is 0.0053 pCi/m³ for samples collected 0–3 miles downwind and 15–20 miles downwind. All values which were not detectable were set equal to these values when average values were calculated.
[b] The applicable AEC radiation protection standard for polonium-210 in air is 20 pCi/m³.

Table 6. Atmospheric monitoring of plutonium–238, Mound Laboratory environs, July–December 1967

Range (miles)	Number of samples	Concentration [a] (pCi/m³)		Average as percent of AEC standards [b]
		Maximum	Average	
0–3 (upwind)	21	0.0264	0.0069	9.86
0–3 (downwind)	21	.0605	.0082	11.71
3–5 (downwind)	21	.1114	.0148	21.14
5–10 (downwind)	21	.0142	.0061	8.71
10–15 (downwind)	21	.0984	.0120	17.14
15–20 (downwind)	21	.0273	.0058	8.29

[a] Lowest detectable limit (LDL) for plutonium-238 in air is 0.0013 pCi/m³ for samples collected 0–3 miles upwind, 3–5 miles downwind, 5–10 miles downwind and 10–15 miles downwind. The LDL is 0.0009 pCi/m³ for samples collected 0–3 miles downwind and 15–20 downwind. All values which were not detectable were set equal to these values when average values were calculated.
[b] The applicable AEC radiation protection standard for plutonium-238 in air is 0.07 pCi/m³.

Table 7. Atmospheric monitoring of tritium, Mound Laboratory environs, July–December 1967

Range (miles)	Number of samples	Concentration [a] (pCi/m³)		Average as percent of AEC standards [b]
		Maximum	Average	
0–3 (upwind)	20	25.00×10^3	0.98×10^3	4.54
0–3 (downwind)	19	26.90×10^3	9.30×10^3	4.65
3–5 (downwind)	19	10.55×10^3	8.13×10^3	4.07
5–10 (downwind)	18	10.69×10^3	8.15×10^3	4.08
10–15 (downwind)	17	8.00×10^3	8.00×10^3	4.00
15–20 (downwind)	18	9.40×10^3	8.08×10^3	4.04

[a] Lowest detectable limit for tritium in air is 8×10^2 pCi/m³. All values which were not detectable were set equal to this value when average values were calculated.
[b] The applicable AEC radiation protection standard for tritium in air is 2×10^3 pCi/m³.

[3] Summarized from "Environmental Monitoring Report:" July–December 1967 and 1967 summary (MLM–1464).

Water monitoring

Liquid radioactive waste materials from polonium and plutonium operations at the laboratory are processed in special waste disposal plants designed to reduce radioactivity to a concentration at which it may be discharged to the Great Miami River.

Helium–3, which is purified at the Mound Laboratory, contains small quantities of hydrogen–3 (tritium). Liquid wastes from this operation are treated separately to assure that the radioactivity level is below the AEC radiation protection standard before discharge to the Great Miami River.

Weekly water samples are collected from a drainage ditch and six locations along the Great Miami River as shown in figure 4. Additional samples are taken quarterly at more distant downstream points. The drainage ditch carries all storm sewer water and treated liquid tritium and plutonium wastes from the plant site. Sampling location number 3 (figure 4) is the point of discharge of the liquid polonium waste to the Great Miami River, and number 7, at Franklin, Ohio, is 5 miles downstream from the effluent outfall.

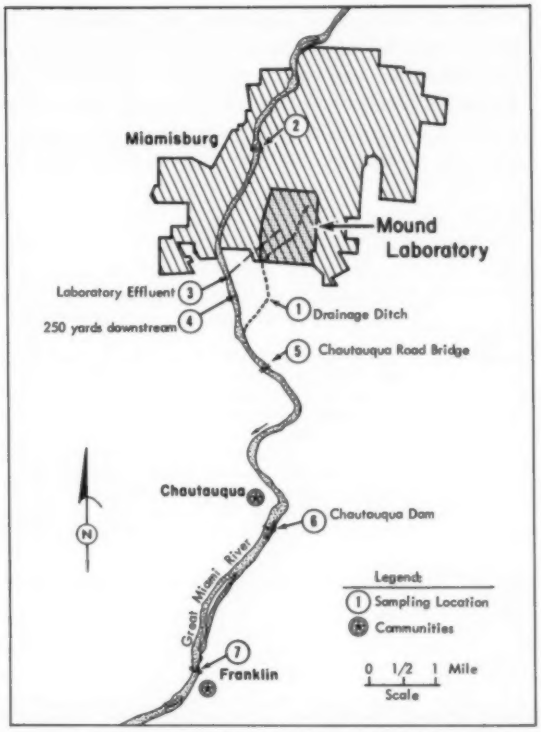

Figure 4. Water sampling locations, Mound Laboratory

Table 8. Offsite water monitoring for radioactivity, Mound Laboratory environs, July–December 1967

Nuclide and sampling location [a]	Number of samples	Concentration (pCi/liter)	
		Maximum	Average [b]
Polonium-210 [c]			
2 (Upstream from laboratory)	23	<1.80	<1.80
3 (Laboratory effluent)	23	1,180.18	86.89
4 (250-yards downstream)	23	<1.80	<1.80
5 (Chautauqua Road Bridge)	23	7.21	2.03
6 (Chautauqua Dam)	23	4.50	1.94
7 (Franklin, Ohio)	23	<1.80	<1.80
Hydrogen-3 (tritium) [c]			
1 (drainage ditch)	23	1.80×10^{-6}	0.22×10^{-6}
2 (Upstream from laboratory)	23	0.63×10^{-6}	$.08 \times 10^{-6}$
3 (Laboratory effluent)	23	16.00×10^{-6}	$.97 \times 10^{-6}$
5 (Chautauqua Road Bridge)	23	$.08 \times 10^{-6}$	$<.05 \times 10^{-6}$
Plutonium-238 [c]			
1 (drainage ditch)	23	23,423.42	1,365.32
2 (Upstream from laboratory)	23	324.32	18.47
3 (Laboratory effluent)	23	1,279.28	101.35
4 (250-yards downstream)	23	18.02	5.41
5 (Chautauqua Road Bridge)	23	207.21	13.51
6 (Chautauqua Dam)	23	<4.50	<4.50
7 (Franklin, Ohio)	23	9.01	4.95

[a] See figure 4 for number of sampling locations.

[b] The applicable AEC radiation protection standards for uncontrolled areas are as follows:
Polonium-210 in water: 7×10^{-1} pCi/liter.
Hydrogen-3 in water: 3×10^{-6} pCi/liter.
Plutonium-238 in water: 5×10^{-1} pCi/liter.

[c] Minimum detectable levels in water are; polonium-210: 1.80 pCi/liter, hydrogen-3: 0.05×10^{-6} pCi/liter, plutonium-238: 4.50 pCi/liter.

All samples which were not detectable were set equal to their respective minimum detectable level when average values were calculated.

All of the river samples are analyzed for polonium–210 and plutonium–238 and some of the samples are analyzed for tritium. The drainage ditch samples are analyzed for tritium and plutonium–238. Average concentrations of tritium, polonium–210, and plutonium–238 are given in table 8 for July–December 1967.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1966 and 1966 summary	November 1967
January–June 1967	April 1968

Reported Nuclear Detonations, August 1968

The U.S. Atomic Energy Commission announced that two nuclear tests of low-intermediate yield (20 to 200 kilotons TNT equivalent) were conducted underground at its Nevada Test Site on August 9 and 29, 1968.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

DETECTION OF ELEVATED FALLOUT LEVELS IN CALIFORNIA, JANUARY 1967. *Amasa C. Cornish and George Uyesugi. Radiological Health Data and Reports, Vol. 9, September 1968, pp. 467–473.*

California received a heavy fallout of radioactive debris beginning on December 27, 1966. Highest air particulate levels occurred in Berkeley and Sacramento; values obtained after allowing 3 days decay were 9$8 pCi/m^3 for both. Other air sampling stations had lesser amounts of fallout and Fresno received essentially no fallout. All milksheds in California were contaminated to some extent with radioactive iodine. Del Norte and Humboldt milk with 397 and 280 pci/liter, respectively, contained the highest concentrations of iodine–131. These values were estimated to result in thyroid doses to children of 33 and 23 mrads, respectively. The apparent half-life for iodine–131 in the environment was calculated to be 3.2 days.

KEYWORDS: California, fallout, foreign nuclear test, iodine–131, milk, thyroid doses.

A COMPARISON OF RESULTS BETWEEN THE PUBLIC HEALTH SERVICE RAW MILK AND PASTEURIZED MILK NETWORKS FOR JANUARY 1964 THROUGH JUNE 1966. *Paul B. Robinson. Radiological Health Data and Reports, Vol. 9, September 1968, pp. 475–488.*

The Public Health Service Raw Milk and Pasteurized Milk Networks are compared for the interval January 1964 through June 1966 on the basis of milk sample analyses made during that period. Once laboratory effects due to analytical differences in the milk sample analyses were removed from the data, the agreement for cesium–137 and strontium–90 between four of the nine stations that were common to both networks was related to milkshed overlap. At two other stations, Cincinnati and Chicago, homogeneity in the agricultural, geographical, and meteorological parameters accounted for the similarity between the sample concentrations of cesium–137 and strontium–90. It was not possible to study iodine–131, barium–140, or strontium–89 because the levels were generally not detectable for the period under study.

A tabulation of data for all samples collected from the Raw Milk Network is also appended for the period January 1963–December 1966.

KEYWORDS: barium–140, calcium, cesium–137, iodine–131, milkshed, pasteurized milk, potassium, raw milk, strontium–89, strontium–90.

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The Government Printing Office style manual is used as a general guide in the preparation of all copy for *Radiological Health Data and Reports*. In addition, *Radiological Health Data and Reports* has developed a "Guide" regarding manuscript preparation which is available upon request. However, for most instances, past issues of *Radiological Health Data and Reports* would serve as a suitable guide in preparing manuscripts.

Titles, authors: Titles should be concise and informative enough to facilitate indexing. Names of authors should appear on the third line below the manuscript title. Affiliation of each author should be given by a brief footnote including titles, professional connections at the time of writing, present affiliation if different, and present address.

Abstracts: Manuscripts should include a 100- to 150-word abstract which is a factual (not descriptive) summary of the work. It should clearly and concisely state the purpose of the investigation, methods, results, and conclusions. Findings that can be stated clearly and simply should be given rather than to state that results were obtained.

A list of suggested keywords (descriptors) which are appropriate indexing terms should be given following the abstract.

Introductory paragraph: The purpose of the investigation should be stated as early as possible in the introductory paragraph.

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